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FIRE CONTROL NOTES

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Forest Service

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

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COVER — This Mars flying boat converted to an air tanker is dropping a 4,500-gallon load on a slash fire in British Columbia. (See story on page 3.)

(NOTE—Use of trade names is for information purposes and does not imply endorsement by the U.S. Department of Agriculture.)

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MARS — NOW GOD OF RAIN

D. N. RADCLIFFE, *Forest Fire Protection Officer,*
MacMillan, Bloedel and Powell Ltd.,
Vancouver, British Columbia

In these days of rocket ships and the superjet it is hard to get excited about an aircraft that has been obsolete for 9 years. But these planes are truly extraordinary. They are the five Martin Mars flying boats, the largest operational flying boats the world has ever seen or probably will ever see. From 1946 to 1956, when the last one was retired, they carried a quarter of a million passengers and countless tons of freight over the Pacific for the U.S. Navy.

Fortunately the Mars story does not end on a scrap heap. It is still being written in the skies over coastal British Columbia where two of the three remaining big transports have been converted to "water bombers" to control forest fires. (One ship was lost by the Navy in a fuel-leak fire in 1950, and one was destroyed in a 1961 crash.

While the four giant boats rested on the beach of the Alameda (Calif.) Naval Air Base awaiting possible destruction from 1957 through 1959, things were getting hotter and hotter for the forest industry of British Columbia. The two bad fire years of 1956 and 1958 convinced fire protection people that better forest fire control methods had to be found, and fast. The water bomber was one technique seriously considered.

Water bombing was not new — a variety of tests between 1930 and 1950 had stirred interest in this novel use of aircraft. Here was the potential for a first-order fireline tool if only a practical carrier could be found. Early experiments were mostly with a water-filled missile dropped from the plane. On very small fires the missile was at times effective, but it was expensive and also a hazard to ground crews.

By 1958 the air tanker was accepted as a part of the fireline team. In British Columbia, five Avengers were in water bomber service, and several Beaver and Otter float planes were equipped with small float tanks.

The small tankers did wonderful work on many small fires, but they didn't carry enough water to be effective on big fires. The ideal air tanker would have to carry a large water payload, preferably several thousand gallons.

Coastal British Columbia is tough flying country, with its steep, high mountains, narrow valleys, and rough air. Traditionally, it is float-plane territory. This rugged coast has few large airfields, but it does have countless sheltered inlets and numerous large lakes. So the choice of aircraft for the ideal tanker soon narrowed down to some type of flying boat. A search for such a flying boat throughout most of 1959 ended at Alameda, where the U.S. Navy was offering the four Mars aircraft for sale as surplus.

Late in 1959 five leading forest industry firms in British Columbia formed a new company, Forest Industries Flying Tankers Ltd.[1] Its purpose was to purchase, convert, and operate the Mars aircraft as water bombers for the member companies. The four aircraft, together with a treasury of spare parts, were purchased and ferried up to Victoria International Airport on Vancouver Island. Here Fairey Aviation of Canada Ltd., with a nucleus of the new tanker crew, started work on a new dimension of water bombers.

The Mars tankers were allocated their own VHF radio frequency, and member companies equipped their logging operations with portable sets for ground-to-air communication. In addition, the Mars tankers carry the radio frequency for the B.C. Forest Service and those of several local airlines. To round out the establishment, an operational base, complete with communications centre, fueling facilities, and crew living quarters, was built at Sproat Lake on central Vancouver Island.

1960

Early in 1960 the first of the converted new tankers was airbound on a series of stiff shakedown tests. By early summer, the tanker moved up to its operational base, ready for business.

The first fire call came on July 4th. Enroute, engine failure forced her to return to base. Four days later, she made four drops on a second fire. Again engine failure forced an early return to base. The trouble was traced to excessive vibration caused by faulty propeller blading.

During the rest of the summer, the Mars made 26 drops on 6 fires, delivering a total of 127,000 gallons of water. These first-year results were inconclusive. The Mars had not controlled any fires singlehandedly. The general opinion was, however, that the results justified continuing the operation with one aircraft.

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[1] The companies were MacMillan & Bloedel Ltd., Powell River Company Ltd., British Columbia Forest Products Ltd., Western Forest Industries Ltd., and Tahsis Company Ltd. In 1961 the new company of MacMillan, Bloedel and Powell River Limited was formed. In 1964 Pacific Logging Limited joined the Flying Tanker Group when a reserve aircraft became operative.

1961

The 1961 fire season started with promise: the tanker did good work on two fires, but that was all — the third fire was its last. Disaster struck. On her first run, the Mars crashed in heavy timber close to the target area, carrying her four crewmen to their deaths.

Since the exhaustive inquiry into the crash by the Department of Transport found nothing to indicate malfunction or structural failure of the aircraft, the cooperating timber companies decided to put another ship into service. The second tanker, overhauled down to the last hull rivet, was ready for fireline duty early in 1962.

1962

When this second tanker moved up to Sproat Lake early in 1962, she was accompanied by a Cessna 195 float plane. This was to be the "bird-dog" plane. Experience had indicated the need for such an aircraft; subsequent fires have proven its worth. First over the fire, the bird dog establishes ground-to-air radio contact, identifies the fireline target, and then leads the Mars in on the best drop path. The bird dog has proven indispensable. In addition to its main job of making the tanker operation safer and more accurate, it acts as handy man around the fire — warning of spot fires or flying the Fire Boss over trouble areas.

In its first year of operation the new tanker saw relatively little action. The 1962 fire season was ideal from the loggers' point of view, with little real hazard. In all, 118,000 gallons of water were dumped on five fires. On the biggest of these fires the true potential of the tanker was recognized. Called in late in the evening, the tanker could only drop two loads before being grounded by dark. Early next morning four loads were dropped along the leading edge of the fire. Unfortunately, a jammed release door forced the aircraft to return to base before the whole front could be wet down. Ground crews were unanimous in their belief that a few more loads would have pinched off the fire and prevented the subsequent spread that required several days to control.

The end of another fire season arrived, and the tanker operation was still under critical scrutiny. The plane had done a creditable job on the few fires it had fought, but mechanical defects had put it out of action more than once. In defense of the Mars it was argued that any single tanker operation is vulnerable to breakdown. Lost time from even a minor breakage requiring base repair is vital on the fireline. The case for a reserve flying tanker was slowly developing.

1963

The year 1963 was by far the best the Mars tanker organization had experienced. Fires were not numerous because the fire season was not particularly hazardous. But, when the tanker was called out, its performance won it full recognition as a member of the fireline team. For the first time the Mars completely extinguished a fire without ground crew support. On a fast-moving lightning fire, it wet down bulldozed fireguards so that firefighters could work in close to the fire front. In two instances the Mars soaked down fire-threatened timber edges to prevent crown fires from starting.

September of that year started out dull and cool. On southern Vancouver Island several operators started to burn slash when rain was forecast. The rain did not fall; instead the weather turned dry. The slash fires, fanned by brisk winds, were soon out of control. The Mars saw more action in 3 days than in any of the preceding 3 years. In 32 runs the tanker dropped 177,000 gallons of water over a wide fire front. Until the sea became too rough, salt water pickups were made offshore from the fire; roundtrips were made in 10 minutes.

By yearend 1963 a record 495,000 gallons had been dropped on nine operational fires. Forest Industries Flying Tankers now was confident the Mars could make a major contribution to fire control. Plans were made to bring a reserve ship into service the following year.

1964

From the point of view of the crews, anxious for action, the summer that followed in 1964 could not have been worse, although it was a blessing for the forests. The crew waited for four miserably wet summer months before they went into action. At year's end they had only bombed two fires! Base activities, however, were far from quiet. The new flying tanker LYL was nearing completion; at the same time major improvements were being built into LYK.

The story of the Mars flying tankers could not be complete without some reference to the men who fly and maintain them, for they are a rather special breed of airmen. A crew of only four men fly the ship on operational tours. Hours of practice have honed the crews into fine precision teams.

A captain, or first pilot, is responsible for the success of the mission and the safety of his aircraft. It is he who must decide whether it is safe to fly in over the fire area, considering terrain, smoke, and air turbulence. Pilots as a basic minimum must have long experience in water operations and mountain flying. Over and above an intimate knowledge of their territory, they must be at ease in smoke-filled valleys bounded by rocky hills. It is one thing to fly over this country at a comfortable altitude, but it is quite another to whistle down barely 250 feet over the treetops through bumpy air. Flying in to pick up a water load the captain takes complete control. He eases the aircraft down until it is planing through the water at precisely 70 knots. When the aircraft is planing smoothly he lowers the probes to start the water pickup (fig. 1).

The second pilot meanwhile is busy with the flaps and trim controls in preparation for takeoff. The moment loading starts the first engineer takes over control of power. In those critical 20 seconds needed to take on a full load he must maintain aircraft speed at 70 knots, then boost power for takeoff.

While flying to the fire, the second pilot listens to radio instructions from the bird dog pilot, who has already identified the first target and by now has lined up the best approach. The captain will make the water drop, but before he starts his bombing run he will probably fly over the fire to confirm the bird dog instructions. Once committed to his run, the captain concentrates entirely on the approach course and altitude. The second pilot takes over the throttles to maintain airspeed at 120 knots. Once past the target he applies climbing power to ensure a safe exit from the fire area.

Engineers double as flight and maintenance crews. Their long suit must be ingenuity in handling emergency repairs in a hurry.

The other member of the crew on the flight deck is the second engineer. When he is not busy watching the maze of instruments on the console to ensure that all systems are running green, he is making frequent inspections of the water tanks and various auxiliary power units.

Back at base the radioman takes over dispatcher duties. He must alert the base crew to any repairs or supplies the aircraft will need on return to base.

In slow years, when fire calls are few and far between, the crew keeps a tight routine of maintenance, training, and base improvement. Within the organization the two operational ships are known by their radio call letters, LYK and LYL.

Water drop studies showed a thousand gallons of water would trail off away from the main target whenever LYK released her load. To reduce this loss, sloping bottoms were fitted into the plywood tanks. The payload was reduced to 4,500 gallons, but the drop pattern was greatly improved. At 120 knots the tanker now can uniformly drench a target area 800 feet long by 250 feet wide. With the reduced water load, extra fuel can be carried to extend operating time.

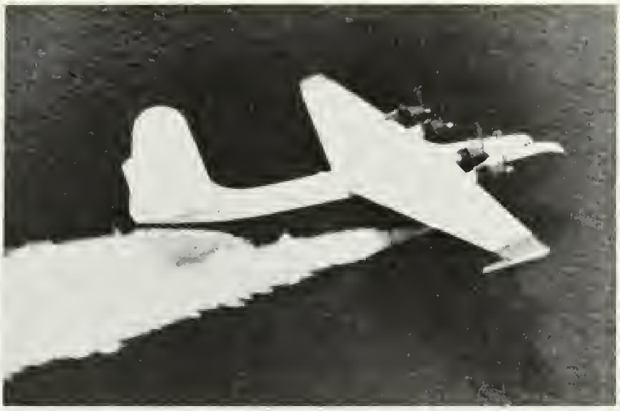

Figure 1.—This Mars flying boat picks up 4,500 gallons of water in 20 seconds while planing at 70 knots.

Perhaps the most interesting modification was the addition of blending equipment. This powdered water-gelling compound effectively concentrates the water load. Drops from an elevation of 500 feet cover the same target pattern as untreated water dropped from 250 feet. This extends the tankers' reach into many a rough corner previously unsafe to approach. The powder is injected into the probes by compressed air as the tanker loads water. Enough powder is carried on board to charge 10 to 12 full loads at a rate of 1 to 1½ pounds per 100 gallons of water.

Unfortunately, these operations are restricted to fresh water, since the compound is incompatible with salt water. Test drops from 250 feet above dense timber plastered the forest floor, windfalls, and vegetation with a quarter of an inch coating of gel over an area 500 feet long and 200 feet wide.

Although now 18 years old, the two operational Mars ships are like new in their smart red and white paint, a vivid contrast to the olive drab of the last reserve ship still parked at the Victoria Airport. The hard-earned tradition of service established in their Pacific transport days is still going strong. In 5 years of flying tanker service, the Mars have dropped 903,000 gallons of water on forest fires. In addition, about 2 million gallons have been released in demonstration and training flights.

When the next bad fire season occurs, the Flying Tankers and their fine crews will be ready. For the harried Fire Boss there is nothing more welcome than his radio calling "This is Bird Dog — how do you read me?" He knows that the tankers will arrive in minutes and that his prayer for rain will be answered.

LOOKOUT TOWER SAFETY IMPROVED

A. B. Curtis, *Chief Fire Warden,*
Clearwater and Potlatch Timber Protective Associations,
Orofino, Idaho

Because more visitors climb lookout towers on the Clearwater and Potlatch Timber Protective Associations' areas each year, improved safety is needed.

Bertha Hill Lookout, on the Clearwater Timber Protective Association area, is one of the oldest (1902) lookout sites in the United States. Many thousands of acres of valuable forest land, publicly and privately owned, can be seen from the lookout. The fifth lookout tower at this location is shown in figure 1.

In 1965 the directors of the Clearwater Timber Protective Association decided that the increasing number of officials and visitors climbing the tower needed more protection. Therefore, a safety net (fig. 2) was installed.

A woven chain link fence material welded to 1-inch iron pipe framework was used. It is similar to the wire mesh behind home plate on a baseball field or the wire netting around a golf course.

The galvanized wire netting was cut in sections, 5 by 20 feet, and four sections, one for each side of the tower, were framed. The 5- by 20-foot wire nets are anchored to the steel walk around sills with hinges at walk level so that the net can be raised or lowered during the winter to prevent snow buildup and the accompanying added weight. Built-in corner sections were also made to protect the four corners. The framework is strong enough to hold several hundred pounds, and the iron piping is adequately braced at about 7-foot intervals to provide a little more rigidity. The wire is number 11 gage, galvanized.

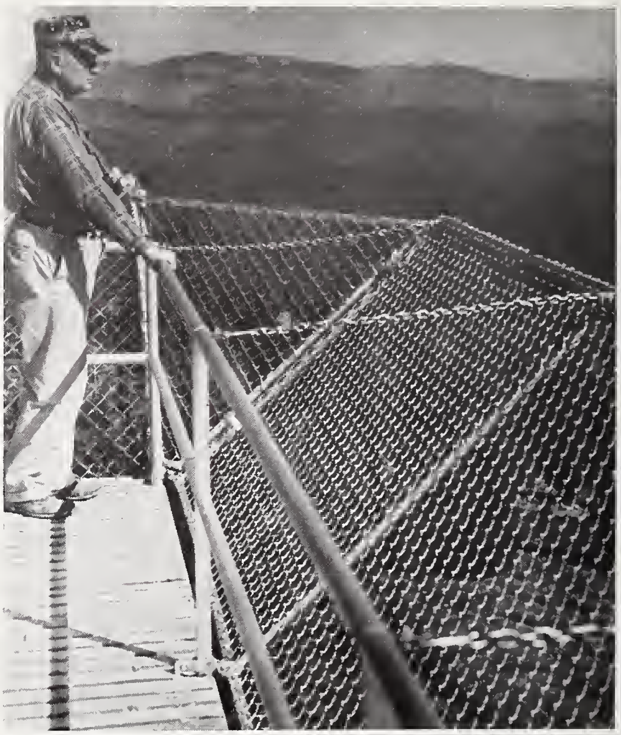

Figure 2.—Safety net on Bertha Hill tower.

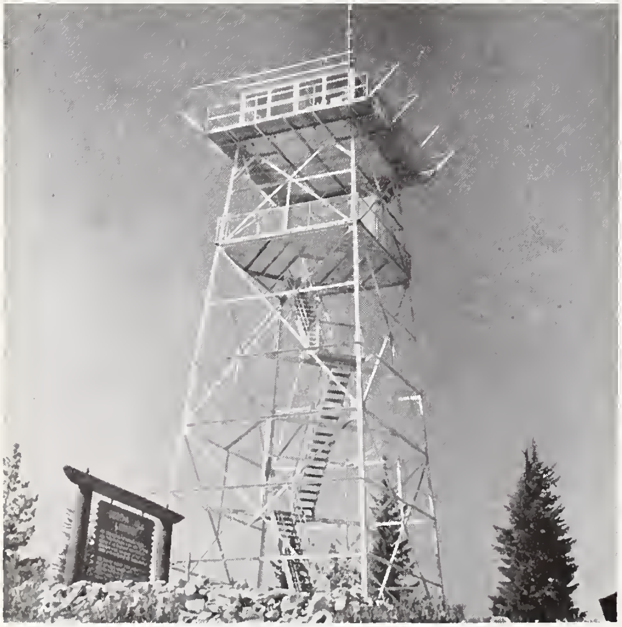

Figure 1.—Bertha Hill lookout tower.

A 100-foot roll of wire fencing costs $40; piping and chains cost 21 and 16 cents per foot, respectively. The total cost of the material was about $88. In addition, laborers were paid $200 to fabricate the material, install it, paint, etc.

The safety net does not seriously impair the lookout man's vision. When smoke is spotted, the mapboard can be moved for satisfactory azimuth readings.

THE HARROGATE FIRE — 15th MARCH, 1964

B. J. Graham, *Bushfire Protection Adviser*

Note: This article is adapted from the South Australian Emergency Fire Services Manual, 1964.

General: The fire started at about 2.30 p.m. in Section 1938, Hundred Kanmantoo, on Mr. Brice's property (fig. 1). The fire travelled mostly east through valuable grazing land and burnt approximately 1,600 acres.

The exact cause of the fire is not known, but after investigations it is thought to have started from a spark from the exhaust of a chain saw.

Fuel type: Most of the area consisted largely of annual grassland; there was a scattering of Eucalypt trees.

Preceding seasonal conditions: The winter and spring preceding the current summer were very *wet*, and the current summer was mild. Therefore, pasture fuels in this area were abundant and completely cured.

Weather of the day: The temperature reached 92° in the afternoon of 15th March, 1964, with a light wind blowing west to northwest. The winds were consistent: the approximate mean velocity was 10 m.p.h.

Fire behaviour: Commencing at Sect. 1938, Hd. Kanmantoo, the fire swept generally east at 2½ m.p.h. The rate of spread of the head fire was affected by such topographical features as creeks and ridges. These features and the country's rocky nature restricted access. Where possible, the flanks were worked by fire crews, and the head fire was confined largely to a front of 90 chains.

By 3:05 p.m. the fire had spread for approximately 70 chains east.

By 3:12 p.m. it had spread for another 60 chains, but the flanks were being controlled and the head fire continued east.

At 3:20 p.m. a pincer movement by units working on both flanks was becoming effective, and the head fire, still moving east, was narrowed to a 70-chain front. The fire had then travelled approximately 2 miles. At about this time the Brukunga Unit was destroyed, and one man (the driver) was badly burned. The farm buildings at White Hut, which were in the fire's path, were saved.

At 3:30 p.m. the head fire hit the Nairne-Harrogate road. It jumped over, but it was controlled after burning 50 acres. The rest of the front was controlled along

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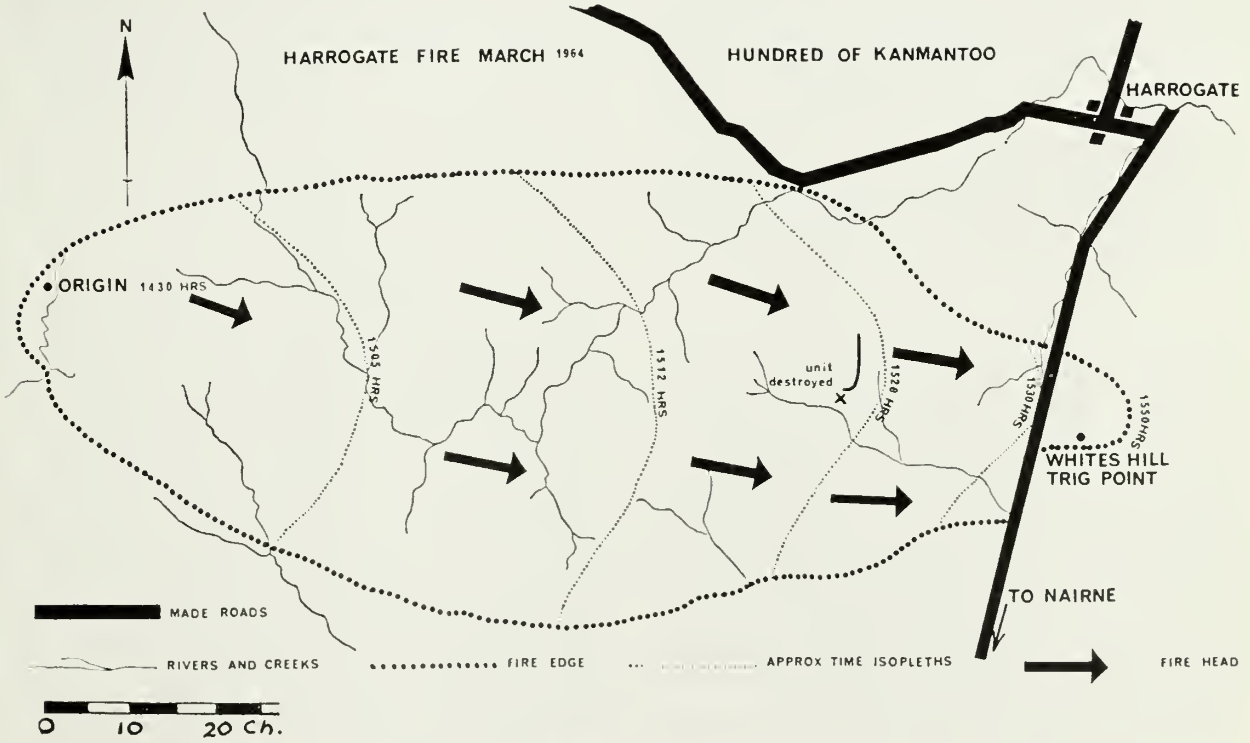

Figure 1.—Progress map of Harrogate Fire.

THE FIRE-BEHAVIOR TEAM IN ACTION—THE COYOTE FIRE, 1964

JOHN D. DELL, *Fire Research Technician*
Pacific Southwest Forest and Range
Experiment Station
Berkeley, Calif.

On a large wildfire, the fire boss bases much of his strategy on information provided by his staff and other assistants. In 1964, fire-behavior teams furnished advice at several forest fires in southern California. Each team, directed by a fire-behavior officer, gathered and analyzed vital information on weather, fuels, and topography. The team concept, originally described by Countryman and Chandler,[1] proved an effective method for evaluating the behavior of fast-moving fires. This note briefly describes how a fire-behavior team operated on the 67,000-acre Coyote Fire that burned on the Los Padres National Forest in September 1964.

ROLE OF THE FIRE-BEHAVIOR TEAM

Team observations and the fire-behavior officer's interpretation combined with reports of scouts and line overhead were extensively used in fire control planning.

An important function of the fire-behavior team is fire-weather observation. By working closely with the U.S. Weather Bureau's fire-weather forecaster, the team saves much time and avoids duplication of effort. Information provided by the fire-weather forecaster includes maps of the latest synoptic weather transmitted by radio by facsimile recorder (FAX) from the U.S. Weather Bureau.

Team members may also make upper air soundings of humidity and temperature or measure the winds aloft (fig. 1).

THE COYOTE FIRE

At 11 p.m., on September 22, 1964, a fire-behavior team was dispatched from the Riverside Forest Fire Laboratory to the Coyote Fire at the request of the Los Padres National Forest. Santa Ana winds, surfacing at night, had swept an almost-controlled brush fire across firelines into heavily populated residential areas. By early morning, the fire, then out of control, had burned more than 600 acres. One of the most devastating conflagrations in recent local history was imminent. However, during the day shift the fire ceased to threaten the residential areas as the Santa Ana winds returned aloft. The sea breeze and upslope wind caused the fire to spread into the mountains (fig. 2).

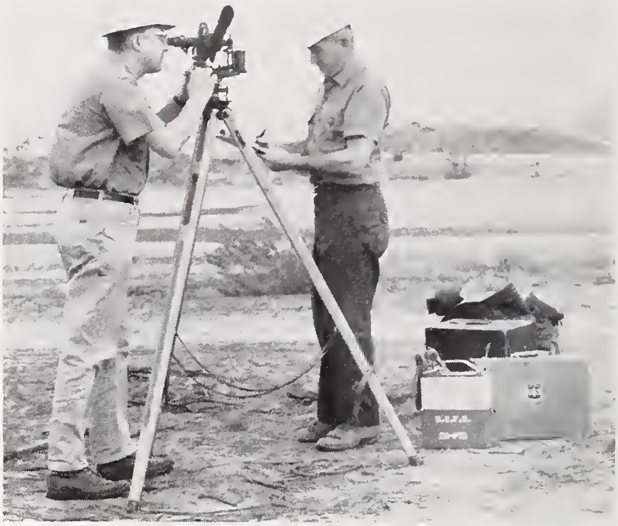

Figure 1.—Fire-behavior team takes a pibal (pilot bolloon observation) with theodolite to determine patterns of local winds aloft.

At the Coyote Fire camp, the fire-behavior officer was briefed by the Weather Bureau's fire-weather forecaster on existing and anticipated weather. The fire-behavior officer made a behavior forecast ready for the Plans Chief before each shift so fireline overhead could be thoroughly briefed. Also, any sudden deviations were explained immediately to the Fire Boss, and a revised forecast was made.

Team members, meanwhile, began taking pilot balloon observations (pibals) of winds aloft, making ground observations, studying preattack maps, and talking with fireline overhead in order to better understand fire conditions. Equipped with its own transportation, radio net, and instruments, the team was able to disperse to various locations on the fire. A communications net linked the team with the fire-behavior officer, and pertinent information was sent regularly. Ground observations were made of temperature, humidity, windspeed, and wind direction; type, density, and condition of fuels in the path of the fire; topography and aspect; current fire behavior; and trouble areas. The fire-behavior team made a thorough surveillance of the area above and to the flanks of the

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[1] Countryman, Clive M., and Chandler, Craig C. The fire behavior team approach in fire control. Fire Control Notes 24(3): 56-60. 1963.

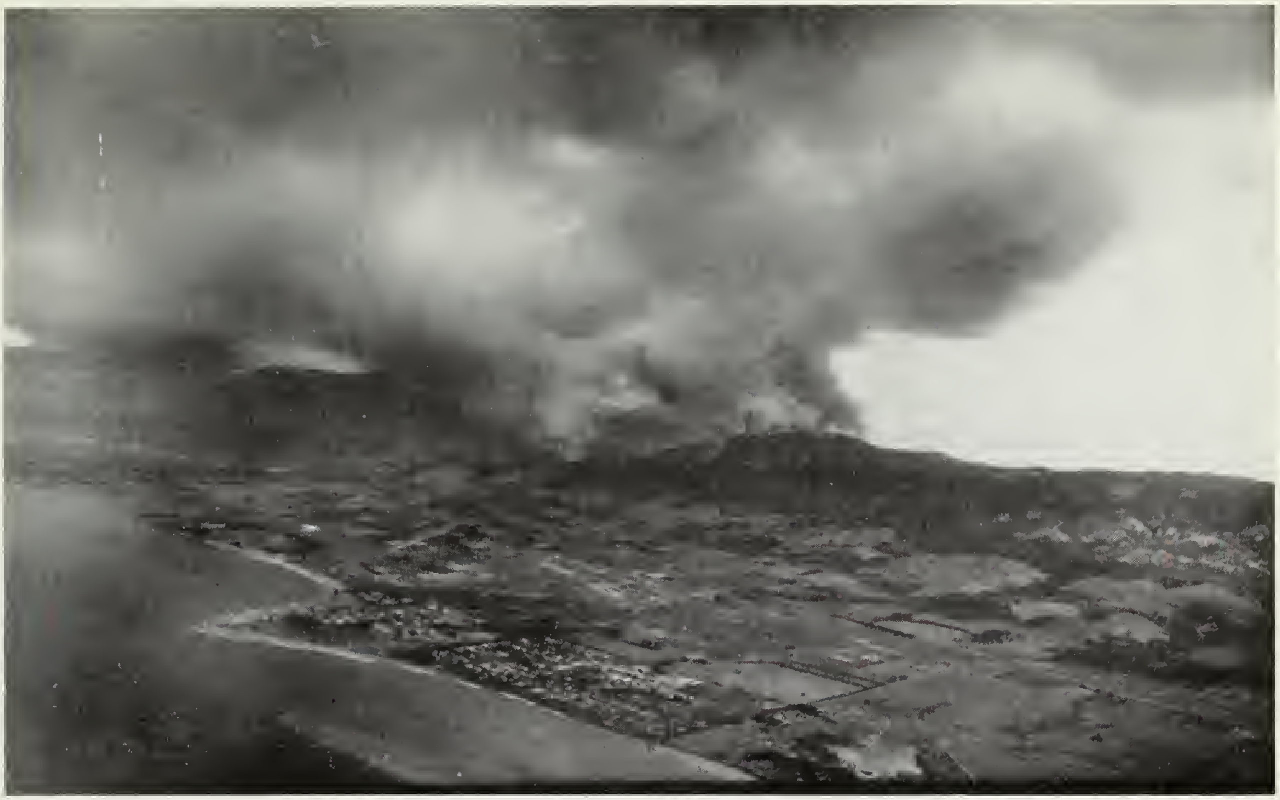

Figure 2.—The huge Coyote Fire near Santa Barbara, Calif., (Sept. 22-Oct. 1, 1964) required the use of three fire-behavior teams. The fire burned more than 67,000 acres of brush-covered watershed.

main front. It noted that strong northeasterly winds were still aloft, although the layer had been rising since morning. The odds were against these winds surfacing as they had the night before, but the forecast indicated this might happen.

Early on the evening of the 23d, a team member was sent to the ridgetop above the fire to observe its behavior and to look for any signs of unusual changes. At 7 p.m., he noted that the humidity had dropped to 14 percent. Light and variable winds gradually developed into a strong northeasterly blast that gusted up to 35 m.p.h. The fire began to intensify on the upper slopes. These factors indicated the fire would probably resume the same pattern as on the previous night—but on a wider front. The fire-behavior team immediately reported these observations to the fire-behavior officer at fire camp. He, in turn, notified the Fire Boss so crews on the line could be warned. By 7:40 p.m., these winds were felt in Santa Barbara.

These winds continued most of the night. At 2 a.m. (September 24), temperatures as high as 92° F. and humidities as low as 10 percent were reported at the Weather Bureau's fire weather mobile unit at the fire camp. Fire again swept through residential areas in the foothills.

By morning the fire had burned along the entire Santa Barbara front, over the ridge, and down into the Santa Ynez River drainage. Personnel were added to the fire-behavior team to increase coverage of the growing conflagration. The fire-behavior officer and part of the team were requested to observe and advise on a critical backfiring operation on the west side of the fire. Another team member made an upper air sounding by helicopter, in order to determine moisture in the lower atmosphere and atmospheric stability over the fire.

In the fire-behavior forecast for the 24th, prepared early that morning, it was predicted that strong Santa Ana conditions would continue at high levels, but would weaken at low levels during the day. It was reported that fuels were very dry and hot runs could be expected where favored by wind or topography. Atmospheric instability would favor the development of large convection columns, spotting, and firewhirls. Santa Ana winds were again likely to surface.

During the next few shifts the Coyote Fire nearly doubled in size. More than 3,000 firefighters from all parts of the Western United States joined in the battle. Zone fire camps were set up at several points around the fire in order to place the manpower where it could be shifted most efficiently. This, of course, created a difficult communications problem for the fire-behavior team. Sending fire-behavior forecasts to all these zone camps over already overloaded communications systems was difficult, yet very essential. Every effort was made to bridge the communications gap and to relay forecasts to all camps, since many of the line personnel from distant forests were unfamiliar with some of the conditions that affect the behavior of southern California fires.

Another fire-behavior team flew from the Northern Forest Fire Laboratory at Missoula. Two more radio-equipped vehicles and extra backpack radios were brought in from Riverside. The fire-behavior officer reorganized and divided his enlarged team and located the shifts at four points around the fire (fig. 3).

Potrero Seco Camp. — The fire-behavior officer and fire-weather forecaster were headquartered here with the mobile weather unit. Team 1 was assigned to take pibals and upper air soundings, and to make ground observations and reconnaissance ahead of fire.

Los Prietos Camp. — Team 2 was assigned ground observations and reconnaissance on the west and northwest sides of fire.

Pendola Camp. — Team 3 was assigned ground observations, pibals, and reconnaissance in the upper drainage area of the Santa Ynez River.

Polo Camp. — One meteorologist was stationed here to take helicopter upper air soundings, ground observations, and reconnaissance on the south side.

Relay. — Here a pickup truck equipped with radio

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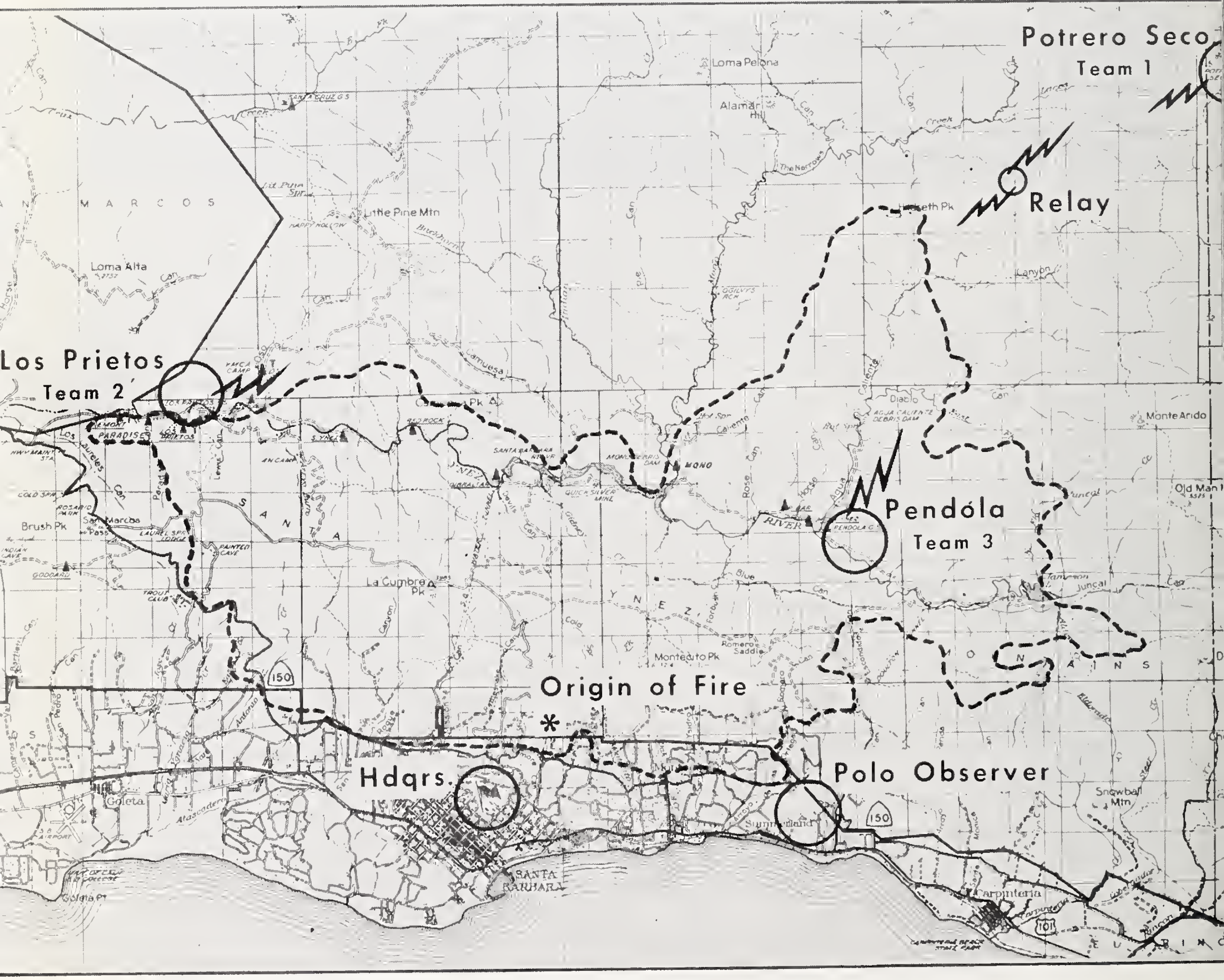

Figure 3.—As the fire spread north, the fire-behavior officer divided and relocated his team for better coverage.

IMPROVED SYSTEM FOR USING FIRE-WEATHER FORECASTS

Howard E. Graham, *Meteorologist,*
Region 6,
Portland, Oreg.

Introduction

Recently, a fire control agency determined that fire-weather forecasts to protect wild lands from lightning fires were not used often enough. This agency had used presuppression protection against possible lightning fires only when the fire-weather forecast called for thunderstorms.

The fire control personnel were insufficiently informed concerning the probability of fire occurrence. When a fire-weather meteorologist was consulted, he said that, to satisfy the public, forecasts had once contained predictions that an event would or would not occur. However, he indicated that much more weather information could now be furnished to fire control officials if forecasts could contain events that had only a certain probability of occurring. He indicated that, for three reasons, uncertainty always exists regardless of how weather forecasts are stated. First, only rather crude measurements can be made of the atmosphere; second, the prediction problem exceeds our ability for exact solution; third, there are unknown and changeable influences on the atmosphere from outer space. The meteorologist was convincing: the fire control agency decided that resources would be more efficiently conserved through systematic use of probability forecasts.

The fire control agency, the meteorologist, and the incident above are fictitious. However, they illustrate a point. The information that follows describes how probability forecasts can be used in fire control. We will specifically refer to thunderstorm forecasts and their use, but probability forecasts can also be used for other weather elements.

Definition of Probability

The most useful measure of the meteorological certainty of any weather event is a statement of mathematical expectancy or probability. We will define probability of thunderstorms, or of any other weather event, as being equivalent to the percentage of frequency of occurrence. For example, if 1,000 forecasts calling for 70-percent probability of thunderstorms have been issued, there should also have been about 700 days with thunderstorms.

Making the Best Decision

Protective measures against expected lightning fires should be taken when the predicted probability of thunderstorms exceeds the ratio of cost to loss. That is, the probability of occurrence of adverse weather should be compared with the ratio of the cost of protective measures to the loss resulting if no protective measures were taken and adverse weather occurred. No proof is given here, but a general derivation has been developed.[1]

The above may be expressed as follows: For the greatest economic benefit,

when $P > C/L$, agency should use extra protection,
$P = C/L$, agency may either protect or not protect,
$P < C/L$, agency should not add extra protection;

where P is the probability of occurrence,
C is the cost of extra presuppression protection, and
L is the loss that would occur if no extra protection were added and the adverse weather occurred.

Illustrating Use of Probability Forecasts

Use of probability forecasts is illustrated in the following example:

A Forest Supervisor decided to obtain the greatest economic utility from probability forecasts of thunderstorms, which were being routinely issued by the fire-weather forecaster.

His first problem was to determine the cost of extra presuppression manning and action for anticipated lightning fires. He found that costs of extra protection varied according to the general level of burning conditions. Average costs per day for extra presuppression manning for expected thunderstorms under given burning conditions were as follows:

Low	Moderate	High	Very High	Extreme
$25	$60	$100	$200	$400

Second, it was necessary to determine the average loss that would occur if no extra protection were provided. This required consideration of three factors:

1. Suppression costs that would have resulted either with or without extra presuppression.

(Continued on page 15)

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[1] Thompson, J. C., and Brier, G. W. The economic utility of weather forecasts. Monthly Weather Rev., v. 83, No. 11, November 1955.

AIR TANKER RETARDANT DROP WARNING DEVICE

I. T. KITTELL, *Dispatcher*
Shasta-Trinity National Forest

Firefighters have been injured severely and even killed by the impact of retardants dropped from low-flying air tankers. To warn ground firefighters of the approach of an air tanker on the final drop run, Joe Noble, safety officer of the Shasta-Trinity National Forest, suggested that an electronic siren be installed in the lead plane directing the air operation or in the air tanker. Because air tankers often operate on initial attack without lead planes, it was decided to install the siren in an air tanker.

The electronic unit provides three functions:

1. The traditional siren sound, a rising and falling wailing sound.
2. A sharp, short series of tones best described as "yelp."
3. A public address system.

After considerable research concerning available equipment, the Region 5 electronics engineer decided that a 24-volt model of a regular transistorized electronic siren/PA system as used for ground fire vehicles would be suitable for an experiment.

Aero Union, an air tanker contractor for both the California Division of Forestry and the U.S. Forest Service at the Redding, Calif., base, allowed installation of this warning system on one of their B-17 air tankers in September 1964. It was mounted on a flat metal plate in the nose of the B-17, aimed forward and down at about a 45° angle from the longitudinal axis of the fuselage (figs. 1, 2).

On aircraft other than B-17's, an adapter may have to be built to allow the forward and downward positioning of the speaker. The system control head is mounted in the cockpit to provide easy access for the pilot or copilot.

The warning system was first used on the Bear Gulch Fire (in rough country) on the Shasta-Trinity National Forest on October 15, 1964. Both the siren and yelp were clearly audible above both aircraft and fire noise. They were audible more than a mile from the fire, depending on elevation of the air tanker, position of the ground firefighters, etc. All on the fire agreed that the device gave ample warning to take cover before the retardant impacted.

The warning system was later tried on several fires on California Division of Forestry and other protection areas. Audibility of the signals was consistently good to excellent. The public address function was not tried while the aircraft was in flight, but it was successful in taxiing and in retardant-loading operations. The PA function, if proven successful in test flights, will be useful in warning firefighters of spot fires or other hazards.

Editor's Note: An air tanker warning device is being developed and tested by the Missoula Equipment Development Center. Permanent installation of such a device is not recommended for U. S. Forest Service use until development and tests are completed and a Forest Service standard is adopted.

(Continued on page 16)

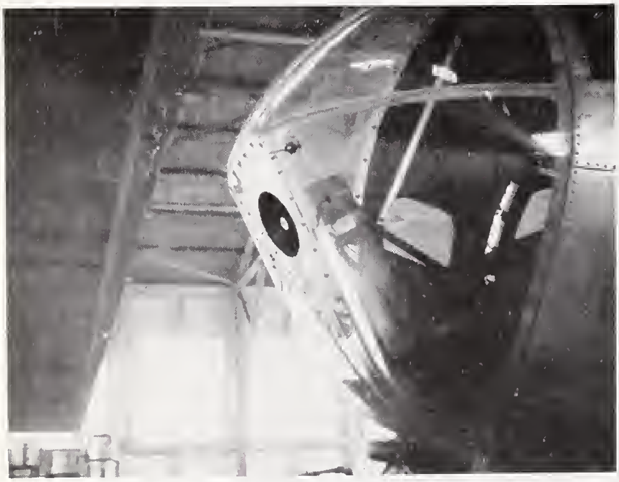

Figure 1.—Exterior view of speaker mounting plate in nose of B-17 air tanker. (Courtesy of Aero Union, Chico, Calif.)

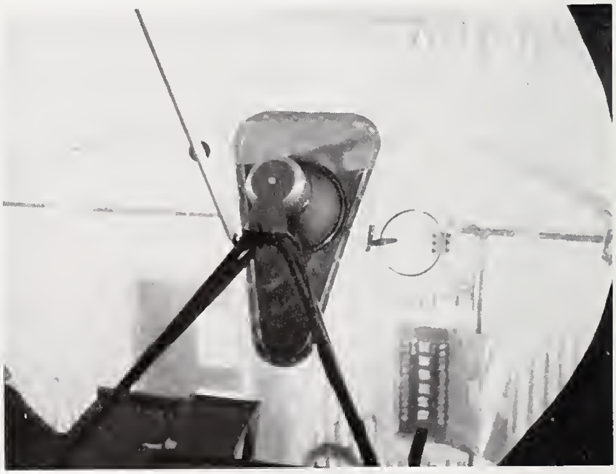

Figure 2.—Interior view of speaker mounting in nose of B-17 air tanker. Interior bracing is shown. (Courtesy of Aero Union, Chico, Calif.)

SMOKEJUMPER AND ADVANCED FIRE CONTROL TRAINING IN THE CALIFORNIA REGION

ROBERT McDONALD, *Forester,*
Northern California Service Center,
Redding, Calif.

Most smokejumper candidates selected from 1957 to 1961 in the California Region were college students. Few were foresters or interested in a forestry career. They jumped a few seasons, then took jobs in their chosen fields. By the end of the 1961 fire season it was obvious that much training and experience was being lost by the rapid turnover in jumpers.

A new approach to recruiting and training smokejumpers has been tried for three consecutive seasons since 1961 with outstanding results. The objective of the new program is to train career fire people in smokejumping and in other fire control skills, thereby increasing their adaptability and broadening their background.

At present men with at least two seasons of fire experience are selected from the Forests. The Forest recommends the man and must be willing to release him for one season for smokejumping and other intensive fire control training. Most of the men selected are already qualified as tank truck operators, crew bosses, or sector bosses.

The training program lasts for 8 weeks. A typical schedule starts with a 5-day field trip. The trainees carry an 80-lb. pack that includes rations, sleeping bags, tools, water, and personal items. They hike 20 miles cross country and have a different camp each night. During the week many subjects are taught that are of importance to the trainees. The week ends with a 6-hour small fire exercise. Two-man crews are required to find a simulated fire in an isolated location, fall a snag, complete a fireline, and then hike to waiting trucks. The exercise requires the use of map, compass, and pacing to find the fire and return to the truck.

Jump training starts the second week (fig. 1). The trainees learn how to exit from an aircraft, steer a parachute, and land. They also learn how to roll, let down in timber, and care for jumper equipment. Several hours are spent on the obstacle course to toughen muscles used in jumping, and also in the classroom on a variety of fire control subjects.

The men make their first practice jumps in the third week (fig. 2). Critiques of the jumps are held in the field, and classroom work continues on such subjects as radio use and procedure, parachute and cargo re-

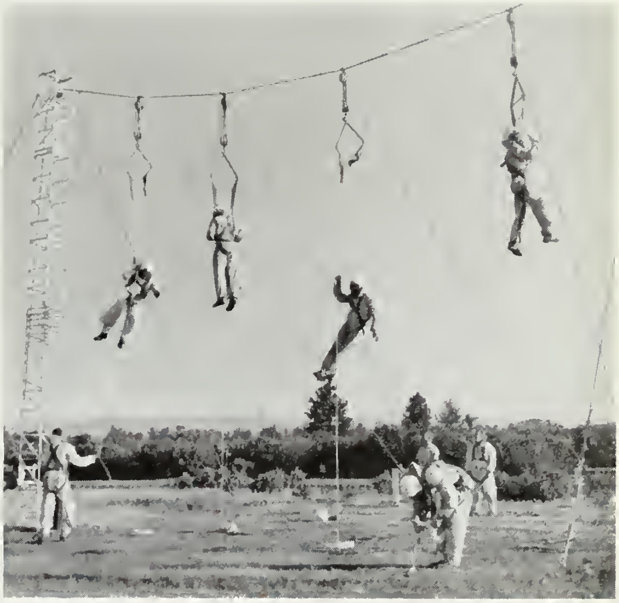

Figure 1—Letdown practice.

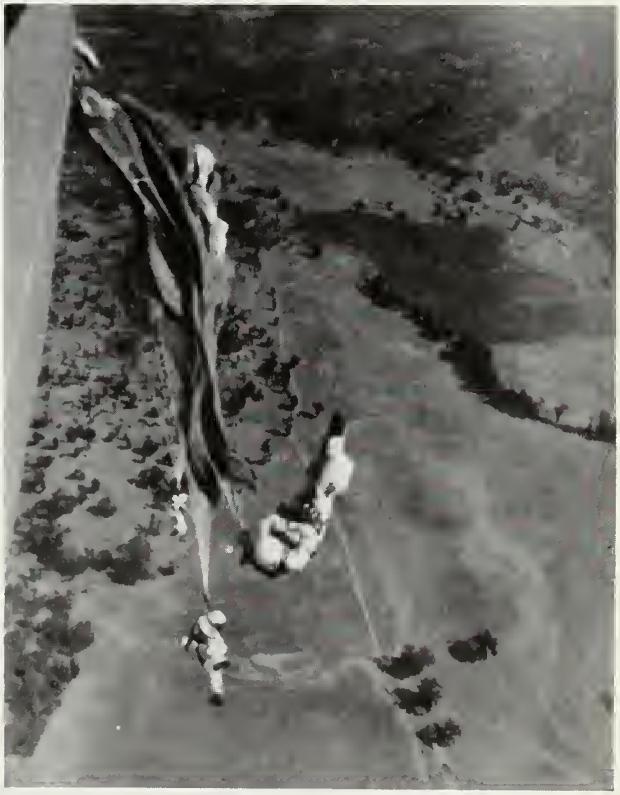

Figure 2.—Practice jumps.

trieving, and fire behavior.

One week is devoted to helicopter and fixed wing aircraft operations. Subjects such as helicopter accessory use, retardant mixing, airport management, air attack procedures, traffic control, and record keeping are taught in the classroom. Field application follows.

The remainder of the course is devoted to leadership and instructor training. There are opportunities for additional self-training to fit individual needs and desires.

During the fire season the men are used either as jumpers or ground fire crews. Because of their fire experience, the top man on the jump list is Fire Boss for that fire. This gives each man a chance to exercise his leadership abilities and practice newly learned skills.

The program has been supported enthusiastically by the Forests. The men jump only one season, then return to their Forests better prepared to advance to more responsible positions. Old jumpers can return each June for refresher jumps. In this way, a reserve of trained men for emergency jumps is maintained.

Advantages of the Program:

1. Better fire control action: jumpers have more fire experience than under previous recruiting procedures.
2. Trained firefighters learn additional skills and receive training not available at the District or Forest level.
3. Additional training to potential supervisory fire personnel.
4. Saves screening over 1.000 applications and establishing register for recruitment of a small number of jobs.

Disadvantages of the Program:

1. Except for four or five cadres, a completely new crew must be trained each year since there are no returnees.
2. Forests may want their men to return before the end of the fire season to fill key fire positions left vacant by students returning to school.

ONE CELL FIRELINE LIGHT

John B. Richards, *District Warden,*
Douglas Forest Protective Association.[1]
Roseburg, Oreg.

Much of the Douglas Forest Protective Association's firefighting is done at night. Therefore, the Safety Committee developed the one cell fireline light (fig. 1). The light, which is primarily used during the laying out of firelines at night, eases the workload of scouts and bulldozer operators and reduces the accident hazard confronting scouts.

The light is made from 16-gage wire with enough tensile strength to retain shape and hold one flashlight battery. The coil on top is two complete wraps and is shaped to permit the insertion of a No. 14 bulb. The bottom is hooked to hold the knob on the positive end of the battery. The battery is inserted with the positive end down. One end is left long so the light can be hung from limbs, brush, and other objects. To aid the insertion and removal of the bulb, the thumb and index finger should be placed at points A and B and squeezing should be done gently.

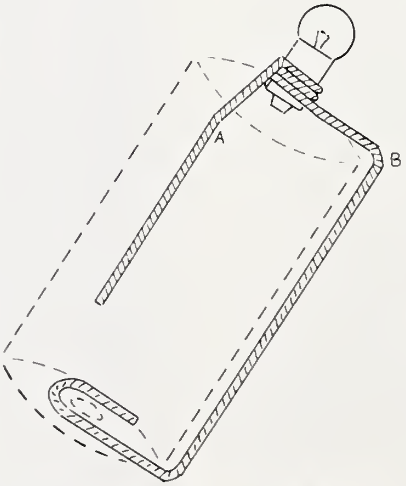

Figure 1.—The one cell fireline light is shown.

The scout places the lights where the fireline should be constructed. He hangs them on tree branches, in the bark of old-growth trees, on top of stumps, and from brush. He works far in front of the bulldozer operator in order to reduce the possibility of logs, trees, rolling chunks, and rocks being loosened by the bulldozer and then striking him.

The lights are readily seen by the bulldozer operator. They enable him to know exactly where the line should be constructed, and they provide him with some visibility of the terrain.

Following fireline construction, the swamper, who is behind the bulldozer, can sometimes retrieve the lights. If he cannot, there is no great loss, for the lights are very inexpensive and easy to make.

---

[1] The Association is located in Douglas County, Oreg.

(*Harrogate Fire*—Continued from page 7)

the road, and the fire was considered under control. The time was 3:50 p.m. The fire units then attacked the southern boundary and quickly obtained control.

Fencing losses: Several miles of fencing were damaged, and approximately 1 mile of it must be replaced. Some fences of sawn hardwood and iron droppers withstood the fire, but the wire components will last for a much shorter period because of the deterioration of the galvanising content.

Firefighting strategy: The organisation and method of attack employed by fire controllers was extremely efficient and resulted in the saving of large areas of heavily grassed land. Seventeen E.F.S. units, capably supported by private units, attacked the fire on the first day, and a lesser number conducted patrolling and mopping-up operations on Monday, 16th March.

The confining of this fire to approximately 1,600 acres is even more praiseworthy when one considers the rocky nature of this inaccessible country and the fact that except for the Nairne-Harrogate road no natural or artificial barrier was near the fire.

(*Coyote Fire*—Continued from page 10)

relayed fire-behavior observations from the roving teams to the fire-behavior officer. The relay system, though makeshift, provided fairly good coverage of the fire, supplied more information on which to base forecasts, and made it easier for the teams to circulate forecasts to the various camps.

About 270 ground weather observations, 40 pilot balloon observations, and 7 upper air soundings were taken during the 6-day period the fire-behavior teams were assigned to the Coyote Fire. From helicopter, truck, jeep, and by walking the fireline, team members observed and reported conditions on the fire almost continually.

CONCLUSIONS

The Coyote Fire provided a good example of the effectiveness of the team approach in fire-behavior coverage of conflagrations. With information flowing in from various locations, the fire-behavior officer has more time to appraise the situation, consult with the weather forecaster, and furnish a more complete and accurate fire behavior forecast. With team members in constant communication, he can be alerted to areas requiring his special attention. The fire-weather forecaster, supplied with frequent weather observations taken by the team, benefits by having more detailed local information on which to base his forecasts.

The fire-behavior team, as employed in southern California during 1964, is certainly not the final answer to fire control problems. It is, however, the best approach yet developed for keeping abreast of the behavior of a forest fire. Equipped with the instruments, tools, and trained personnel to do the job, fire-behavior teams offer a service that — if properly used — can contribute to more effective fire control operations.

(*Fire-Weather Forecasts* — Continued from page 11)

2. Resource loss from fire.
3. The various levels of burning conditions.

Loss estimates were difficult to obtain. However, the average loss per day from lightning fires when there was no extra presuppression protection under given burning conditions was as follows:

Low	Moderate	High	Very High	Extreme
$10	$80	$200	$670	$2,000

Third, each category of cost is divided by the same category of loss. Thus, the ratio of cost to loss for each category of burning conditions is as follows:

Low	Moderate	High	Very High	Extreme
1.00	.75	.50	.30	.20

Therefore, the Forest Supervisor should never use extra protection for predicted thunderstorms when the burning condition is Low. It is Moderate when a 75-percent or greater probability of thunderstorms was predicted. Extra protection would also be used when the burning condition is High with a forecast of 50 percent or greater probability; when Very High with a forecast of 30 percent or greater probability; and with an Extreme burning condition and a forecast of 20 percent or greater probability.

Conclusions

Use of judgment or use of the principles discussed above may result in the same decision. However, the complexity of the problem is usually too great to be handled efficiently through judgment. Utilization of forecasts based on probability of occurrence generally provides better results. However, more research is needed in order to more systematically apply the results of fire-weather forecasting to the problems of fire control.

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(*Warning Device*—Continued from page 12)

To reduce the tanker pilot's operations during a critical time (the drop run), the warning activation switch should be wired into the aircraft retardant tank door arming circuit. This would activate the warning signal when the doors are armed for dropping, normally only at takeoff and on the drop run. Also, the pilot would not have to remember to turn on the warning system.

Ground-level sound pressure and area coverage measurements of the electronic siren/PA system operated in aircraft at various altitudes are scheduled to be made during 1965 by the R-5 Electronics Branch.

To assure safety and reliable performance, complete standards covering the installation of electronic sirens in aircraft must be developed.

ELECTRONIC SIREN UNIT SPECIFICATIONS

1. Name: Fyr-Fyter Penetrator Electronic Siren and PA Unit (for 24/28-volt aircraft, Model 24 PT75; for 12/14-volt aircraft, Model 12 PT75.
2. Components:
   A9 SP75 Speaker. Noise-cancelling microphone. Audio input for the siren unit may be integrated into the plane's radio microphone selector system so that the existing microphone may serve the PA function.
3. Power:
   Output . . . 75 watts with single speaker
   Voice:
      Idle 0.5 amperes
      Talk 3.0 amperes
   Siren:
      Maximum 3.5 amperes
      Minimum 4.5 amperes
4. Weight:
   Cockpit control head 7 pounds
   Speaker 7 pounds
5. Dimensions:
   Cockpit control head 3½ x 7 x 6 inches
   Speaker
      Diameter 8⅜ inches
      Vertical 8¾ inches
6. Cost with non-noise-cancelling PA microphone: $309.00 list price.
7. Source: L. N. Curtis & Sons, 4133 Broadway, Oakland, Calif.

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FIRE CONTROL NOTES

U.S. Department of Agriculture
Forest Service

FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

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COVER—This pile burst into flame shortly after ignition. It was treated with a 30-gallon dilution of one part asphalt emulsion and two parts water. See story on page 5.

(NOTE—Use of trade names is for information purposes and does not imply endorsement by the U.S. Department of Agriculture.)

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USE OF TAMARIX TREES TO RESTRICT FIRES IN ISRAEL[1]

YOAV WAISEL and JACOB FRIEDMAN,
Department of Botany, Tel-Aviv University, Israel

Fire hazard in arid and semiarid regions is High during the dry and hot summer. Usually field and forest fires start along roads where cigarettes or exhaust sparks are thrown from motor vehicles and ignite the dry litter.

Fire hazard usually depends on three environmental characteristics:

1. Susceptibility of the plant material to ignition.
2. Temperature of the fire and type of burning produced.
3. Abundance, density, and ground position of fuel.

For example, fire races through dry remnants of grasses and herbaceous plants because straw is readily ignited, produces high, hot flames, is abundant in large, contiguous areas, and is dense enough for continuous fire propagation and yet spaced widely enough to secure sufficient oxygen.

The combustibility of wood and fabrics may be lowered considerably when they are impregnated with certain ions.[2] Broido and Nelson (1964)[3] noted that the susceptibility of corn straw to inflammation is inversely correlated to its ash content. They declared that the use of plants with a high ash content may reduce the fire hazard.

To reduce the fire hazard along roads in arid and semiarid regions, isolated strips free of combustible material are usually cleared. However, such clearing has to be repeated annually, sometimes has to be done by hand, is difficult to complete, and is expensive. Therefore, this article explains an alternative method for reducing this hazard.

In geographical regions where herbaceous plants supply most of the fuel for fires, planting of isolation strips with tree species that eliminate annual herbaceous undergrowth and produce highly fire-resistant litter may reduce the number and progress of wildfires.

USE OF TAMARIX *RESTRICTS FIRES*

A short survey of the trees in Israel revealed that trees with all of the above desirable characteristics do exist, and that some of these belong to the genus *Tamarix*.

The litter of *Tamarix* trees has a high mineral content (sometimes more than 19 percent of the dry weight). Furthermore, the plants are salt excreters, and salty drops drip from the trees almost every night[4] [5].

Litter Accumulation Reduces Fire Hazard

Thus, in semiarid climates, the soil below these trees is rapidly covered with shedded salty twigs, accumulates much salt, and eliminates plant species that do not grow naturally on highly salty soil[6] [7]. The depression of the plant undergrowth below *Tamarix* trees is not only remarkable below adult trees, but also below 3-year-old saplings, where the effect of shade is still insignificant (fig. 1). Such a depression of the undergrowth is advantageous in the reduction of fire hazards below and across *Tamarix* plantations.

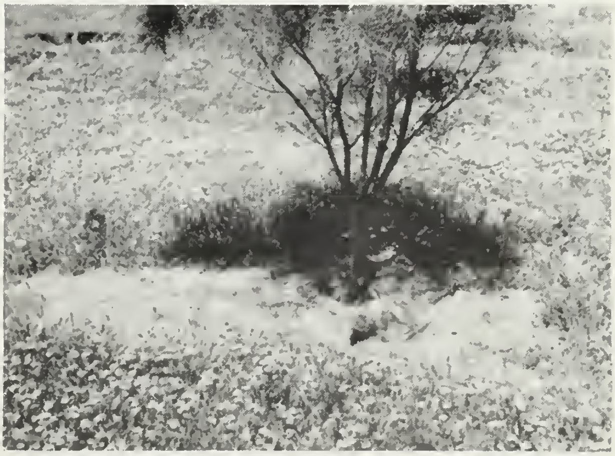

Figure 1.—The elimination of herbaceous plants below a 3-year-old sapling of *Tomarix ophyllo*. (near Gevuloth, Israel, April 1965.)

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[1] Adapted from "The Use of *Tamarix* Trees For The Restriction of Fires," which was published in La-Yaaran, Israel.

[2] Lewis, M. 1964. U.S. Pat. 3150919.

[3] Broido, A., and Nelson, M. A. 1964. Ash content; its effects on combustion of corn plants. Science 146:652–653.

[4] Waisel, Y. 1960. Ecological studies on *Tamarix aphylla* (L.) Karst. II. The water economy. Phyton 15:17-27.

[5] Waisel, Y. 1961. Ecological studies on *Tamarix aphylla* (L.) Karst. III. The salt economy. Plant and soil 13:356–364.

[6] Litwak, M. 1957. The influence of *Tamarix aphylla* on soil composition of the Northern Negev of Israel. Bul. Res. Council Israel 6D:38–45.

[7] Friedman, J., and Waisel, Y. 1964. Contribution to the arboreal flora of Israel: *Tamarix aphylla* (L.) Karst. La-Yaaran 13:156–161.

Tamarix *Litter Resists Ignition*

The shedded twigs of *Tamarix* trees form a compact layer on the soil. Repeated field experiments revealed that the ignition of this type of litter is extremely difficult (figs. 2, 3). The litter of *Tamarix* resists fire not only because of its geometry. Even in the laboratory this twig litter is very difficult to ignite; usually a high-temperature gas torch is needed. Even when the litter is set on fire, the flames produced at the ignition point do not cause further burning, and when the igniting torch is removed the flames die.

Data on fire velocity in different plant litter are presented in table 1. Fire progressed rather fast through the grassstraw and pine needles, but in the litter of *Tamarix* it rapidly died. Thus, there is almost no fire hazard due to fire progress in such material.

The material used in the experiments reported in table 1 was ovendry. Thus, the results confirm the idea of Broido and Nelson (1964) that it is the ash content rather than the water content that results in the difference in burning between pine needles, hay, and *Tamarix*. This idea is further supported in experiments which compared the burning of natural litter of *Tamarix* with that of a litter which was thoroughly leached and ovendried at 85°C. 24 hours before the experiment. While the natural litter was hardly ignited, the leached material exhibited a slow but continuous flame.

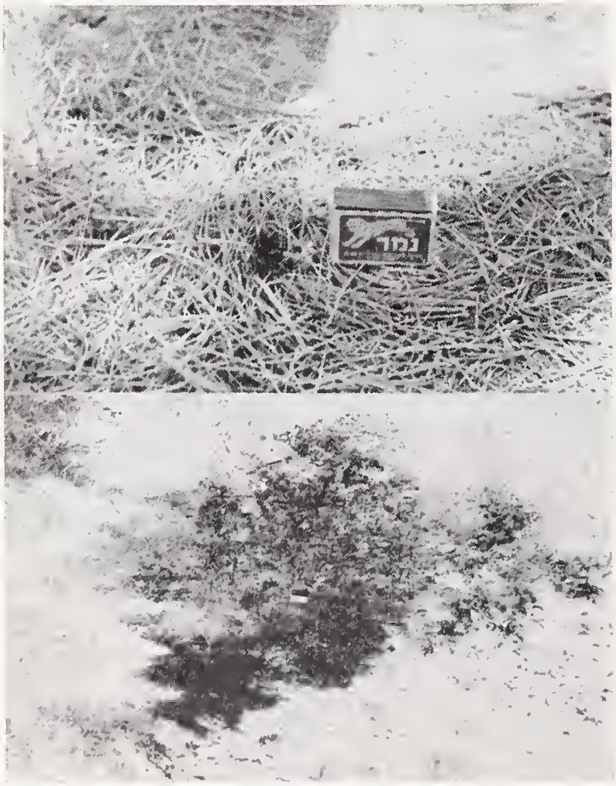

Figure 2.—The dimensions of a burned spot ignited with a single match: Top, litter of *Tamarix aphylla*; Bottom, straw of the herbaceous plants in the same area.

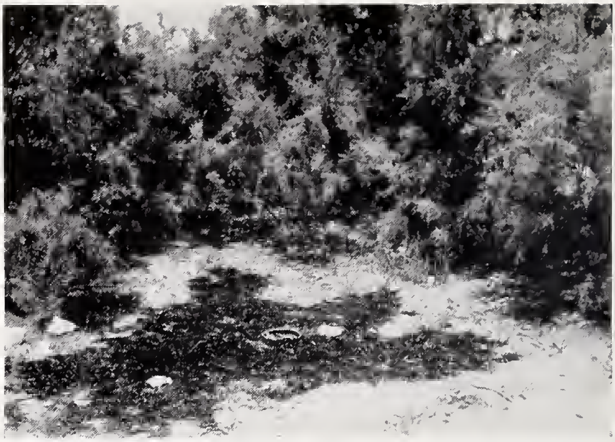

Figure 3.—The site of extinction of a fire which was advancing towards a stand of *Tamarix gallica*. The outlines of the unburned strip overlap the area where the shedded litter accumulates.

TABLE 1.—The progress of fire through a strip of uniformly prepared, ovendry plant material (2 cm. thick and 5 cm. wide). Gun powder (450 mg./ 4 cm.^{2}) was used as a prime.

Time since ignition (seconds)	*Distance from ignition point*		
	Pine	Hay	*Tamarix*
	Cm.	*Cm.*	*Cm.*
10	3	8	3
25	5	11	([1])
50	10	18	([1])
75	15	23	([1])
100	23	29	([1])

[1] Fire extinguished.

Additional Advantages of Using Tamarix

Nevertheless, high moisture content of the litter still reduces the ability of plant debris to catch fire. The litter of *Tamarix* is superior even from this viewpoint. Due to the hygroscopic salt crystals covering the twigs, and due to its high mineral content, the litter is highly hygroscopic. The litter below *Tamarix* trees is often wet, not only during the night, but also a few hours after sunrise and an

(Continued on page 15)

PROTECTIVE COATINGS OF ASPHALT AND WAX EMULSIONS FOR BETTER SLASH BURNING

HARRY E. SCHIMKE and JAMES L. MURPHY,
Forest Fire Laboratory,
U.S. Forest Service, Riverside, Calif.

Disposal of logging slash is one of the biggest problems confronting the forest manager. He cannot burn during the summer because fires may escape. During the wet winter he can safely burn, but fuels often are too wet. He needs a method of keeping slash dry. Protective covers of tar paper, kraft paper, and plastic have been used. However, they are expensive, and wind can tear or displace them.

In 1961 Kirkmire[1] said that asphalt and wax emulsions sprayed on slash showed promise for speeding slash disposal.

Similarly, McNie[2] said that coating slash piles with asphalt and wax helped permit safe slash burning. Also, this operation cost less than previous methods. However, the fire control staff on the Klamath National Forest[3] in northern California found that treating slash on steep ground with an asphalt emulsion was expensive. Furthermore, workers had considerable difficulty handling, mixing, and applying the material. In a feasibility study in the winter of 1962-63, we found that slash piles sprayed with asphalt and wax emulsions could be burned during the winter when untreated piles could not. Also, the cost of applying asphalt to slash was about one-half that of covering slash with plastic.

THE STUDY

The study of the previous winter was enlarged in the winter of 1963-64, and this note reports the results of this later research. The 1963-64 study was conducted on the Duckwall Conflagration Control Experimental Area, Stanislaus National Forest, near Sonora, Calif. Station personnel met research employees of a company which develops and produces asphalt and wax products. They decided that three asphalt products and two wax emulsion products should be tested. These were asphalt emulsion Grade SS-1 ("Laykold Slash Cover"), asphalt emulsion Grade RS-1, priming solution (Asphalt cutback), a soil sealant wax emulsion, and a lumber sealant wax emulsion. Mixing ratios (asphalt or wax emulsion to diluent) of 1:1, 1:3, and 1:5 were used. Diesel fuel was used for diluting the priming solution, and water was used for the other four products.

Each of 45 piles (5 by 5 by 4 feet) of mixed conifer slash was treated with 6 to 10 gallons of solution. There were nine piles per product and three piles per mixing ratio. Fifteen more piles of the same type of slash were left untreated to represent controls. All piles were coated in the late fall when completely dry (fig. 1). The slash piles were burned on three dates:

November 15, 1963, when 2 to 3 inches of rain made slash burning safe.

January 29, 1964, when 6 inches of snow was on the ground and precipitation had totaled 17 inches.

April 23, 1964, when precipitation totaled 22 inches.

Each pile was ignited by a drip torch. The following were measured:

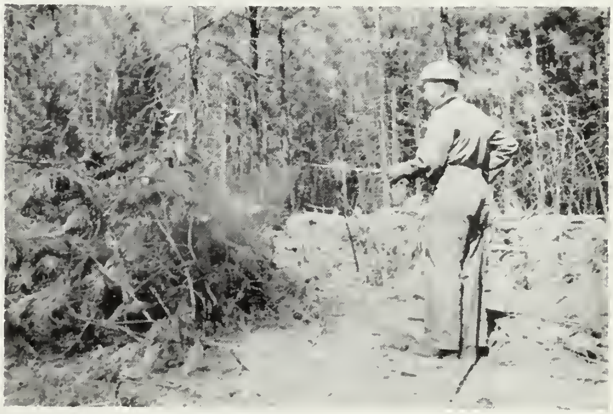

Figure 1.—Forest worker spraying asphalt emulsion on slash pile.

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[1] Kirkmire, N. Report on preliminary tests of water proofing sprays for logging slash. 1961. (Unpublished report on file at Wash. Forest Protect. Assoc., Seattle, Wash.)

[2] McNie, John C. The role of water in burning right-of-way debris. 1963. (Report given at West. Forestry and Conserv. Assoc. Ann. Meeting, December 1963.)

[3] Report on the asphalt emulsion SS-1 treatment of logging slash in clear cut blocks. 1963. (Unpublished report on file at Klamath National Forest, U.S. Forest Serv., Yreka, Calif.)

Report on asphalt emulsion SS-1 treatment of right-of-way piled construction slash. 1963. (Unpublished report on file at Klamath National Forest, U.S. Forest Serv., Yreka, Calif.)

1. Time to ignite each slash pile, that is, the time required for fire to burn independently of the ignition device; and the number of times rekindling was necessary.

2. Time from ignition to the time the fire went out either because the fuels were consumed or would no longer burn—usually because of wetness. This time is called the burning time.

3. The degree of slash disposal. Three classifications were given:

Very satisfactory.—Pile ignites well, burns rapidly, hot, and clean, and little residue is left.

Satisfactory.—Pile ignites with some difficulty, burns moderately well, and leaves residue up to 3 feet long.

Unsatisfactory.—Pile does not ignite or ignites with difficulty, burns poorly or not at all, and leaves total pile or much residue in pile or perimeter (fig. 2). Perimeter residue exceeds 3-foot length.

4. Average fuel moisture percentages obtained from random samples of three size classes of slash material (0 to one-fourth inch, one-fourth to 1 inch, and more than 1 inch) in each test condition in February and April.

Observations were made and photos were taken of smoke output from coated and uncoated piles because smoke may be a smog threat in some areas.

Beads of recent precipitation that clung to the treated piles made ignition somewhat more difficult than in the untreated piles. This moisture dissipated rapidly, however, and the slash was much drier and burned quicker and cleaner.

RESULTS

Ninety-one percent of the slash piles sprayed with a protective coating and 40 percent of the uncoated piles burned satisfactorily. The coated piles also ignited somewhat quicker than the uncoated piles. The average moisture content of coated piles was 41 percent less than that of the untreated piles.

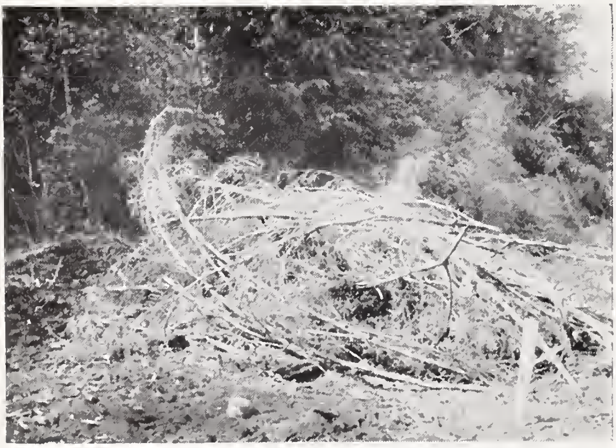
Figure 2.—This photo was taken after the initial attempt to ignite this pile. It was untreated and used as a control.

The slash was protected best by the SS-1 grade asphalt emulsion, priming solution, and the lumber sealant, in that order, and by the heavier mixes (no thinner than 1:2).

Because the slash was drier, the total output of smoke (slash plus coating) from coated piles was much less than that from uncoated piles.

RECOMMENDATIONS

From the experience gained in these field tests, we recommend the following:

Consider Alternative Methods

Preplanning may suggest that chipping, swamper burning, burying, spring burning, or other methods are cheaper and/or better.

Construct Slash Piles With Care

Piles should be compact, free of dirt, and large enough to build up heat to consume all the material.

Select Best Available Coating

Availability and cost of material and equipment will determine which coating is best.

The availability, cost, and performance of the SS-1 asphalt make it our first choice. However, it was a little more difficult to handle than the wax and primer. It cost about 30 cents per gallon in the supplier's 55-gallon drum and about 20 cents per gallon in bulk.

Our second choice is the priming solution, which protects slash well because it spreads and penetrates well. But it requires equipment that can tolerate petroleum. It cost about 50 cents per gallon (in supplier-furnished drums at plant). When the cost of the solvent is added, the total cost nearly equals that of the wax. Diesel fuel cost 15 cents, kerosene, 20 cents.

The lumber sealant wax was easy to work with, not messy, and sealed well. Its use will be limited, however, for it cost about 75 cents per gallon in drums furnished by the supplier at his plant. Costs of application will vary with type of material, equipment used, availability of coating material, type of slash, and the mixture used. The average cost of asphalts or waxes was $20 to $30 per acre. The cost for treating a cubic foot of slash averaged about one-half cent.

(Continued on page 15)

SLASH DISPOSAL BY CHIPPERS

WAYNE R. COOK, *Forester,*
Black Hills National Forest

ADVANTAGES OF CHIPPING

For disposal of logging or thinning slash, chipping has many advantages over piling and burning or broadcast burning.

Chipping may be done throughout the year. Best results are obtained when the material is green, but frozen or dry slash may be chipped.

Chipping slash can reduce the potential rate of spread and resistance to control of fire in recently logged over areas. Chipping also eliminates the need for costly piling and waiting for proper burning conditions.

Chipping does not reduce and can enhance aesthetic values; this is vital along highways and near recreation areas. It is the only practical method for concurrent slash disposal and cutting. Also, chips decompose quicker than normal slash.

CREW SELECTION

Crews must be well organized, trained, and supervised. Crew size depends on the distance the material must be hauled and on the capacity of the machine. A three- or four-man crew can usually keep the chipper working at capacity in ponderosa pine thinning slash. For safety, only one man at a time should feed the chipper.

WORK PLANNING

Best results are obtained when cutting methods are determined and chipper routes are laid out and mapped prior to commercial timber stand improvement. All trees are felled in one direction so that butts point one way and less handling is required. Windrowed material can be fed to the chipper continuously (fig. 1).

SELECTING CHIPPERS

In choosing a chipper, the size of material to be chipped must be considered. Most chippers can handle material with diameters up to 4½ inches, and some, 8 inches.

For economy, the chipper should have enough horsepower and torque to handle material continuously. Sufficient power on a weighted flywheel enables the cutting head to rotate uniformly. To reduce blade damage, a series of small blades staggered on the cutting head, rather than one large blade, should be used.

The unit should have an adjustable bonnet on the chip exhaust head. The bonnet adjustment should allow for 180-degree rotation and for some change in elevation. Thus, the distribution of chips can be controlled from the chipper to insure an even coverage over the ground or for side or end loading into trucks.

The Black Hills National Forest operates seven chippers. Five of these are mounted on trailers and towed behind conventional or four-wheel-drive pickups or small tractors, depending on terrain and ground condition. The other two units are self-propelled—the chipping heads have been incorporated into modified four-wheel-drive vehicles.

COST

The cost per acre, based on a commercial cut of 2,500 board feet per acre, averages $60 and ranges from $34 to $120.

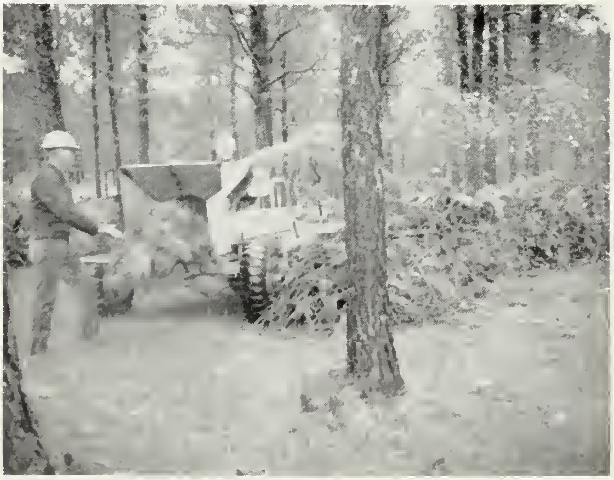

Figure 1.—This self-propelled chipper is being used on windrowed brush piles.

THE "C" AND "D" ALERT SYSTEM, AN ATTACK PLANNING TOOL

DANIEL C. MACINTYRE, *Forester,*
Lincoln National Forest

A difficulty in fire control planning is that the plans, once down on paper, are inflexible to some extent, whereas the fire itself is fluid. In obtaining flexibility of plan, however, there is the danger of being vague in one or more of the plan components. For development of flexible yet precise presuppression planning, the most promising area is between the ranger district or initial attack unit, and the zone or regional coordinated project fire organization.

The "C" and "D" Alert System strengthens the intermediate planning level between the ranger district direct attack unit and the full project fire organization. It is designed for fires in the "C" and "D" class, 10-300 acres, that occur during critical weather conditions, and often just beyond the resources of the average ranger district to control. Its objective is to contain hard-to-handle fires within the first burning period. It has the fluidity and quick mobilization of the ranger district organization, combined with the planning advantages of the project fire organization.

For the Southwest the three essential parts of the "C" and "D" Alert System are:

1. Prepackaged overhead teams for
   a. The Class C-Alert System, for 10-50 acre fires.
   b. The Class D-Alert System, for 50-300 acre fires.
2. Guides to provide for automatic dispatching of predetermined amounts of supplies, equipment, and crews.
3. A training plan, which will introduce the new system and teach the principles of sound fire organization and management. Not only professional people but GDA's, forestry technicians, and fire control aids should receive this training.

PREPARING THE SYSTEM

Overhead Team

In setting up a "C" and "D" Alert System, the first step is to decide on the particular configuration of overhead teams needed for the Forest or other combination of ranger districts. This is usually done by a panel of local fire experts. Figure 1[1] is an example of a C-Alert team. In this example no service chief or campboss position was provided, and the service and plans functions were combined.

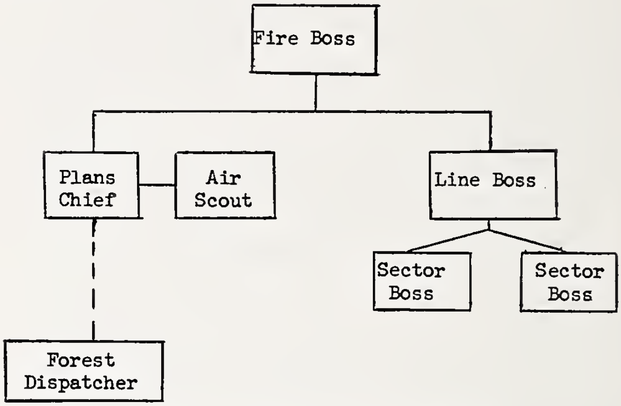

Figure 1.—Typical C-Alert overhead team.

The D-Alert team is designed for the worst burning days, when it is recognized at first report that the fire will require more organization than the elementary C-Alert team can provide. The D-Alert team also functions as a backup organization, in case of imminent failure of the C-Alert team. Figure 2 is an example of a D-Alert team.

After deciding on the size and configuration of these teams, the panel should make a master list of forest personnel qualifying for as many team positions as possible. The list must be revised throughout the season by the Fire Staff Officer to account

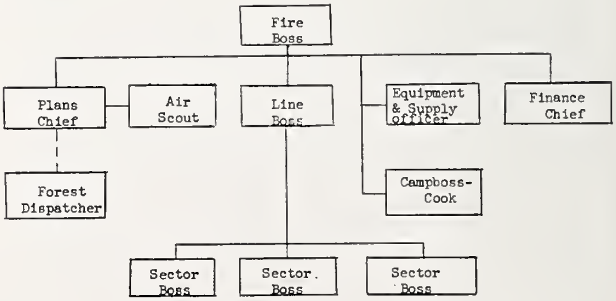

Figure 2.—Kaibab D-Alert Team, 1962 season.

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[1] The dispatcher is recognized as part of the overhead team in this chart and in the forms that follow. Since our whole effort here is toward speed and efficiency early in the fire, it would be folly to ignore the pivotal role of the dispatcher.

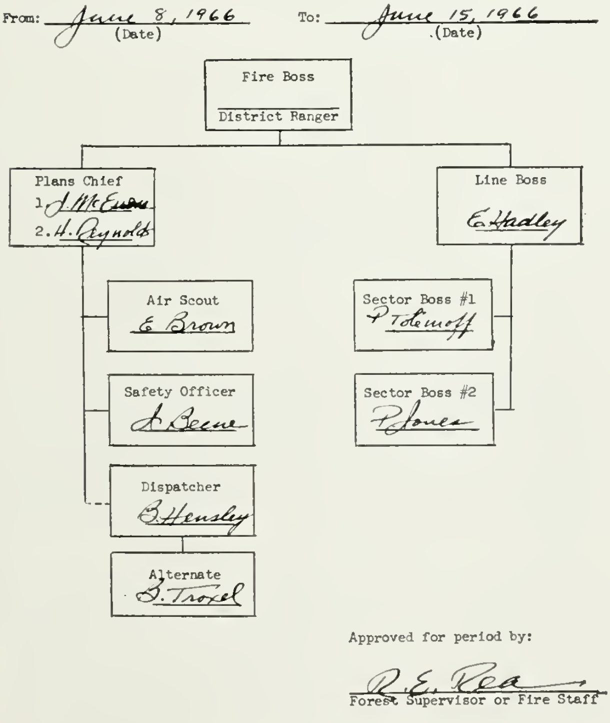
for transfers and demonstrated performances, and annually by the panel.

During critical fire season the overhead teams are packaged weekly. On Wednesday morning the forest dispatcher fills out a Class-C Alert and Class-D Alert duty roster from the master list. The assigned duty is 1 week, until the following Wednesday morning. Figure 3 shows how the overhead team is planned from week to week. On some forests the fire boss position is filled by the district ranger, if at all possible, and his name is written in after the organization is alerted. Because of a general shortage of qualified plans chiefs, two people are usually assigned for plans chief duty. This double scheduling allows a district ranger who is a qualified plans chief to be preassigned for plans duty. The alternate plans chief is assigned to the fire if it is on his district.

The dispatcher then notifies the district rangers and the fire staff officer of the week's selection. After their approval, and with their help, he notifies the selected personnel. From the time of notification to the end of the duty period, these people remain in constant radio or telephone contact, keeping the dispatcher advised of their location.

Dispatcher's Guide

The dispatcher's guide should list the resources of men and materials that are needed and practical in most troublesome "C" and "D" fires in critical fire season.



From: June 8, 1966 (Date) To: June 15, 1966 (Date)

Fire Boss

District Ranger

Plans Chief
1. J. McEwen
2. H. Reynolds

Line Boss
E. Hadley

Air Scout
E. Brown

Sector Boss #1
P. Tolemoff

Safety Officer
J. Beene

Sector Boss #2
P. Jones

Dispatcher
B. Hensley

Alternate
B. Troxel

Approved for period by:

R. E. Rea
Forest Supervisor or Fire Staff

Figure 3—C-Alert duty roster.

DISPATCHER'S MATERIAL AND SUPPLY GUIDE

for Class C-Alert Fire

Dispatcher ______________ Date ________

Assistant Dispatcher ______________ Time ________

Name of Fire ________

	Dispatched	ETA
Men and Overhead—2 Crew Bosses		
20 Crewmen		
2 Men for J. Deere 2010		
4 Men for Pumper Crews		
Vehicles and Equipment		
2 Pumper Units		
1 John Deere 2010		
1 Water Trailer, 250 gallon		
3 Powersaws with Equipment		
40 Man Tool Cache		
4 Sets Catapillar Lights		
Radios 4 Handy Talkies		

As an alert is set in motion, the dispatcher immediately sends out men, equipment, and vehicles as the guide indicates, recording the dispatched time. The fire boss or plans chief has copies of the guide as kit components and need only order additions or deletions to what is contained therein. A second benefit of the guides is a substantial reduction in radio traffic during the fire emergency.

Training Plan

Because the Southwestern fire season may begin as early as March 15, the overhead school is held in early spring. At the school trainees are introduced

(Continued on page 16)

RATE OF FOREST FIRE SPREAD AND RESISTANCE TO CONTROL IN THE FUEL TYPES OF THE EASTERN REGION

W. G. BANKS,[1] *Research Forester,*
North Central Forest Experiment Station,
and H. C. FRAYER,[1] *Former Staff Assistant,*
Branch of Fire Control, Eastern Region

Information about the rate of spread of forest fires helps fire control planners delineate hour-control zones and the required strength of initial attack and total forces, and it helps suppression forces make tactical decisions.

Rate-of-spread tables prepared by Jemison and Keetch (1942)[2] have been used in the Eastern Region for many years. However, since 1942, the danger-rating system has been changed, and instrumentation and methods of measurement have been improved.

In 1959, the Eastern Regional office of the U.S. Forest Service decided to study recent fire reports to correlate rate of spread with the current fire-danger rating system, and to compare the more recent rate-of-spread data with the 1942 data. The Northeastern Forest Experiment Station cooperated with the Eastern Regional office in reviewing their individual fire reports, Form 929,[3] for 1950–58 from all National Forests in the Eastern Region.

Burning index, wind, and slope were to be considered in computing rates of spread for each fuel type. Unfortunately, wind and slope data were missing from many reports, so only the burning index data could be used.

The definitions of fuel types used in this study have been used in the Eastern Region for many years. They were also used in the earlier studies of fire spread by Abell[4] and by Jemison and Keetch. A list of these fuel types by number and description follows. Tables 1–5 refer to fuel types by number only.

Fuel type (number)	*Description*
1.	Northern conifers, 4 inches d.b.h. and larger.
2.	Northern conifers, cutover, duff and no slash.
3.	Hardwood and hemlock-hardwood, cutover, no duff nor slash.
4.	Northern and Appalachian hardwood, 3 inches d.b.h. and larger.
5.	Hardwood reproduction.
6.	Southern pine, 6 inches d.b.h. and larger.
7.	Southern pine reproduction.
8.	Conifer slash (new).
9.	Conifer slash (old).
10.	Hardwood and southern pine slash.
11.	Grass, ferns, and weeds.
12.	Plantations.
13.	Laurel and rhododendron.
14.	Scrub oak.
15.	Unburnable.

RATE OF SPREAD

For all fires in each of the various fuel types, the average perimeter increase in chains per hour between discovery and attack varied from 4.9 for northern conifers 4 inches d.b.h. and larger (fuel type 1) to 27.1 for southern pine reproduction (fuel type 7). The average for all types was 21.9 (table 1).

Since the fastest-spreading 25 percent of fires normally account for much of the area burned, and for even more of the damage, the average perimeter increase in chains per hour for each type was computed for this group. These increases varied from 11.9 chains for fuel type 1 to 64.8 chains for fuel type 7, and averaged 51.7 chains (table 1).

The rates of spread for 1930–41 and 1950–58 were compared (table 2). For those fuel types with 50 or more fires in each period, the rates of spread were very similar. When fewer than 50 fires occurred in one or both periods, the differences in rates of spread were usually large.

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[1] When this research was conducted, Banks was stationed at the Northeastern Forest Experiment Station, Upper Darby, Pa. Frayer is now retired.

[2] Jemison, George M., and Keetch, John J. Rate of spread of fire and its resistance to control in the fuel types of eastern mountain forests. 1942. U.S. Forest Serv. Appalachian Forest Expt. Sta. Tech. Note 52, Asheville, N.C., 15. pp.

[3] Superseded by Form 5100–29.

[4] Abell, C. A. Rate of spread and resistance to control data for Region 7 fuel types and their application to determine strength and speed of attack needed. 1937. U.S. Forest Serv. Appalachian Forest Expt. Sta., Asheville, N.C., 7 pp., illus.

TABLE 1.—*Average rate of spread of all fires and of the fastest-spreading 25 percent of fires, by fuel types* (Eastern Region, 1950–58)

Fuel type No.	All fires				Fastest-spreading 25 percent of fires	
	Fires	Average perimeter increase	Standard error (S –) X	Standard deviation (S)	Fires	Average perimeter increase
	No.	*Chains per hour*	*Percent*	*Chains per hour*	*No.*	*Chains per hour*
1	9	4.9	42.0	6.3	2	11.9
2	13	12.8	26.0	12.1	3	28.7
3	7	6.4	47.0	8.0	2	16.1
4	742	21.2	4.4	25.4	186	52.2
5	348	20.8	5.5	21.3	87	46.7
6	58	22.6	16.8	28.7	14	56.5
7	60	27.1	13.8	29.2	15	64.8
8	5	7.6	43.8	7.4	1	15.5
9	9	23.4	25.4	17.9	2	43.6
10	101	24.8	9.1	22.6	25	55.3
11	182	26.6	7.2	25.8	46	59.7
12	7	20.1	43.1	22.9	2	50.3
13	24	18.8	33.5	31.0	6	52.5
14	17	17.8	21.0	15.4	4	36.6
15	7	17.3	40.4	18.5	2	44.6
All types	1,589	21.9	2.8	24.5	397	51.7

The combined data for the two periods probably represent the best information available on rate of spread in the Eastern Region (table 2). These combined data showed that 12 fuel types differed in their mean rate of fire spread by less than 15 percent. Types 1, 8, and 15 differed by more than 15 percent, but their rates of spread were the lowest.

For 1950–58, the average perimeter increase per hour for all fires, and also for the fastest-spreading 25 percent of fires, were computed for four burning-index (B.I.) ranges (table 3). The increase in rate of spread, for each of the three steps upward in burning-index ranges, averaged approximately 38 percent. This further indicates that successful fire control must be closely related to a burning index or some other measure of burning conditions.

The distribution of 1950–58 fires by rate-of-spread and burning-index range is shown in table 4. As expected, the percentage of fires that spread at the higher rates increased as the burning index increased. For example, only 3 percent of all fires that occurred when the burning index was in the range 1 to 11 spread at 50 chains or more per hour, whereas 27 percent of all fires that occurred when the burning index was 100 or more spread at this speed.

All spread data shown in this study are for the

TABLE 2.—*Comparison of rates of spread, by fuel types* (Eastern Region, 1930–41 and 1950–58)

Fuel type No.	Fires			Average perimeter increase of all fires			Average perimeter increase of the fastest-spreading 25 percent of fires		
	1930–41[1]	1950–58	Combined	1930–41[1]	1950–58	Combined	1930–41[1]	1950–58	Combined
	No.	*No.*	*No.*	*Chains per hour*	*Chains per hour*	*Chains per hour*	*Chains per hour*	*Chains per hour*	*Chains per hour*
1	14	9	23	12.1	4.9	9.3	21.7	11.9	17.9
2	24	13	37	30.2	12.8	24.1	86.7	28.6	66.3
3	55	7	62	22.3	6.4	20.5	55.7	16.1	51.2
4	914	742	1,656	20.7	21.2	20.9	47.4	52.2	49.6
5	634	348	982	21.5	20.8	21.3	51.3	46.7	49.7
6	161	58	219	22.7	22.6	22.7	53.0	56.5	53.9
7	97	60	157	25.1	27.1	25.9	55.2	64.8	58.9
8	15	5	20	15.8	7.6	13.7	35.8	15.5	30.7
9	12	9	21	26.2	23.4	25.0	67.5	43.6	57.3
10	141	101	242	25.4	24.8	25.1	60.9	55.3	58.6
11	516	182	698	26.8	26.6	26.7	58.8	59.7	59.0
12	....	7	7	....	20.1	20.1	....	50.4	50.3
13	7	24	31	33.1	18.8	22.0	83.2	52.5	59.4
14	13	17	30	35.6	17.8	25.5	85.2	36.6	57.7
15	....	7	7	....	17.3	17.3	....	44.6	44.6
All types	2,603	1,589	4,192	22.9	21.9	22.5	52.7	51.7	52.3

[1] Jemison and Keetch 1942.

early period of the fire between discovery and attack. This is usually limited to the first hour of the fire, frequently to the first half hour. Though these data are of value in helping determine initial-attack strength, they should not be misinterpreted as representing the rate of spread after the fire has gained momentum.

RESISTANCE TO CONTROL

Resistance to control, as considered here, is the relative difficulty within various fuel types of constructing and holding a fireline with hand crews. Although fire control has become more mechanized, such comparisons are still desirable.

Recording *man-hours to control* only, to the nearest 10 on the individual fire report, Form 929, has made calculations based on data from this source subject to large errors, particularly because many fires were small, requiring 30 or less man-hours to control. For example, in recording to the nearest 10, a fire that required 16 man-hours to control would be recorded as 20 man-hours—a difference of 25 percent between actual and recorded. To compensate for this discrepancy, the fire control staff of the Eastern Region Forests critically reviewed the resistance-to-control classifications, as computed from individual fire report data, and suggested adjustments. In applying these adjustments to the resistance-to-control classifications, they rated two fuel types as extreme, seven as high, four as medium, and two as low (table 5).

TABLE 3.—*Average rate of spread of all fires, and of the fastest-spreading 25 percent of fires, by burning-index ranges* (Eastern Region, 1950-58)

Burning-index range	All fires		Fastest-spreading 25 percent of fires	
	Fires	Average perimeter increase	Fires	Average perimeter increase
	No.	*Chains per hour*	*No.*	*Chains per hour*
1–11	274	13.7	69	34.3
12–35	691	19.6	173	48.6
40–95	548	26.7	137	61.6
100+	62	37.6	15	87.7
All ranges	[1] 1,575	21.7	394	52.1

[1] Fourteen fire reports showed no burning index; thus, they could not be used.

TABLE 4.—*Percent of fires spreading at various rates, by burning-index ranges* (Eastern Region, 1950-58)

Burning-index range	Fires	Perimeter increase per hour			
		Less than 30 chains	30 chains or more	50 chains or more	70 chains or more
	No.	*Percent of fires*	*Percent of fires*	*Percent of fires*	*Percent of fires*
1–11	274	88	12	3	1
12–35	691	80	20	8	4
40–95	548	66	34	15	7
100+	62	63	37	27	14
All ranges	[1] 1,575	76	24	10	5

[1] Fourteen fire reports showed no burning index; thus, they could not be used.

TABLE 5.—*Resistance to control by fuel types* (Eastern Region, 1950–58)[1]

Fuel type No.	Resistance-to-control class[2]
1	High
2	High
3	High
4	Medium
5	High
6	Medium
7	Medium
8	Extreme
9	Extreme
10	High
11	Low
12	Medium
13	High
14	High
15	Low

[1] Adjusted by fire control staff of the Eastern Region.

[2] Class standards for resistance to control: 2.5+ chains of held line per man-hour = Low; 1.8 to 2.4 chains = Medium; 1.1 to 1.7 chains = High; 1.0 or less chain = Extreme.

SUMMARY

Studies based on Eastern Region fire reports indicate that fuel type is not an extremely important factor in the rate of fire spread during the early period of the fire. Data for all fires for two periods, 1930–41 and 1950–58, show that for 12 of the 15 fuel types the rate of spread ranged within 15 percent of the mean of the 12 types. Data for the fastest-spreading 25 percent of fires show that for 11 of the 15 fuel types the rate of spread differed by no more than 10 percent from the mean of the 11 types.

The rate of spread increased substantially with increases in the burning index. As expected, the percentage of fires spreading at the higher rates increased substantially as the burning index increased.

Resistance to control, or the relative difficulty of constructing and holding a fireline with hand crews, differed appreciably by fuel types. Two fuel types were classed as Extreme, seven as High, four as Medium, and two as Low.

NEW MAP FOR SMOKECHASERS[1]

Missoula Equipment Development Center,
Missoula, Mont.

In a few years smokechasers will probably stop using the familiar folding map consisting of pocket-sized squares glued to cloth backing. A remarkable paper developed for industry is used for maps that have superior utility and cost one-tenth as much as the cloth-backed type.

The paper is "Tex-O-Print." Developed for shipping tags and labels, Tex-O-Print is impregnated with latex to resist abrasion and wetting, the two main injurers of smokechaser maps. Tex-O-Print maps are light, tough, and thin, and have excellent detail when printed by economical color lithography.

As many as 250 smokechaser maps have been prepared annually in Region 1 by the cut-and-paste method. The average annual cost was $2,550; about $2,300 was paid to workers who tediously cut maps into small squares and glued them to the cloth backing, leaving folding space between each square.

Some advantages of the Tex-O-Print maps follow:

1. They cost approximately $1, about $9 less than the old maps.
2. Tex-O-Print's toughness has eliminated the need for cloth backing.
3. The new maps when folded are one-fourth as bulky as the old ones.
4. On only the new maps, grease pencil delineations can be made and removed.
5. Only the old maps must be cut into small rectangles, thus disturbing the planimetric details.

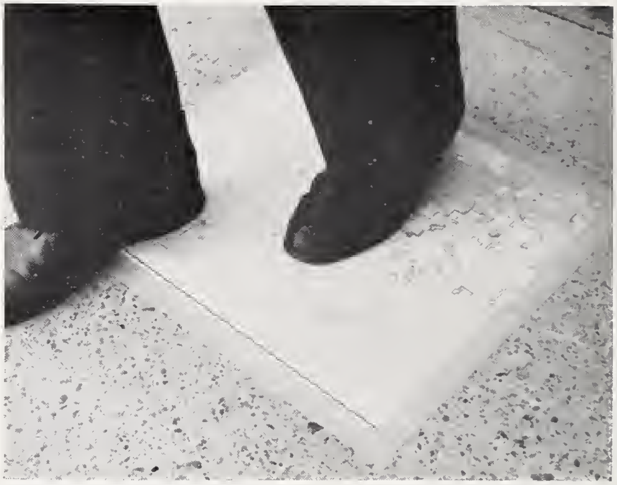

Figure 1.—People walked on a Tex-O-Print map as part of a durability test.

6. Only the old type of maps can be destroyed by damp weather and water. One Tex-O-Print map was taped to the sidewalk in front of a building. It was walked on by people entering and leaving (fig. 1). After 21 days of exposure to this treatment and to rain, snow, and sunshine, the map was wiped clean with a damp cloth. It was scuffed but serviceable.

Tex-O-Print maps used normally should last 5 years. During 1964, five R-1 Forests tested the new maps. Because reports were enthusiastic, the Region is supplying Tex-O-Prints as existing map stocks become exhausted. Tex-O-Print smokechaser maps are now approved for Service-wide use.

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[1] J. W. Burgess, Division of Engineering, Region 1, Missoula, Mont., proposed use of Tex-O-Print for Forest Service maps.

BUTANE BOTTLE BLITZES BIVOUAC

HOWARD V. SHUPE, *Forester,*
Coronado National Forest

On July 7, 1965, the men at the Carrisito fire camp on the Coronado National Forest had been making progress in containing a 600-acre brush fire. The night crew had bedded down where a mesquite tree or a desert shrub provided shade from 106° F.

Then it happened. A spare butane bottle exposed to the sun reached its maximum pressure and blew the plug. The bottle was only 7 feet from operating gas burners, and the escaping gas drifted into the open flame. With the resultant explosion and liquid gas pouring forth, the bottle was converted into a giant undulating blowtorch. More nearby tanks soon exploded. The flames spread rapidly into the dry, parched fuels within and surrounding the camp, and tents and other equipment were consumed by flames. Men ran from the area, and vehicles were quickly moved.

(Continued on page 15)

(Butane Bottle—Continued from page 14)

Fortunately, fatalities or serious injuries, which were likely, did not occur. To prevent similar incidents from happening, the following safety precautions are recommended:

1. That open fires and fuel bottles not in use be at least 25 feet apart.
2. That extra fuel bottles be stored separately from fuel bottles in use.
3. That fuel bottles used where it is 100° F., or more, be filled to 80 percent of capacity to allow for expansion.
4. That shading be provided for fuel bottles whether they are in use or not.

(Tamarix Trees—Continued from page 4)

hour or two before sunset. The chances of a fire below a *Tamarix* plantation during these hours are negligible.

A long smouldering fire is hazardous because new fire outbreaks may occur with the onset of wind. *Tamarix* again seems superior due to the fast extinction of fire in its litter as well as in its burning wood. (table 2)

TABLE 2.—Data on flaming and smouldering of 10 grains of ovendry samples of pine needles, hay, and litter of *Tamarix*. Gunpowder (450 mg./4 cm.^{2}) was used as a prime.

Unit of measure	Pine	Hay	*Tamarix*	
			Natural	Leached
Time from ignition to extinction of flame (seconds).	60(55–65)	47(45–50)	14(5–20)	112(105–120)
Time between extinctions of flames and glare (seconds).	312(235–380)	301(210–435)	7(5–10)	170(160–180)
Loss of weight due to burning (percent)	84(80–89)	64(59–69)	4(2–6)	50(46–55)
Ash content (percent)	7.0(6.4–8.0)	8.0(7.6–8.3)	19.6(19.4–19.8)	15.6(15.2–16.2)

As shown in table 2, a fire of *Tamarix* litter extinguishes rapidly and burns only a minute fraction of the sample. However, the samples of hay and pine needles are burned thoroughly, and the resulting weight loss is 64–84 percent of the sample's dry weight. The duration of flaming and especially of smouldering in hay and pine is much longer than in *Tamarix*.

When the litter of *Tamarix* is thoroughly leached, and its mineral content is reduced from 19 to 15 percent, it burns more readily. However, even then the leached litter burns slowly, smoulders only briefly, and extinguishes before complete combustion.

Tamarix trees are easy and inexpensive to propagate; their growth rates are usually very high, and the large number of species spread over the world makes at least some of them available for planting in a large variety of regions. Thus, together with the above-mentioned characteristics found in Israel, it seems worthwhile to try and use *Tamarix*-planted isolation strips for the restriction of wildfires.

(Protective Coatings—Continued from page 6)

Mix Carefully

Mix one part emulsion to two or not more than three parts solvent (diesel fuel or kerosene for primer, water for others).

Coat Slash When It Is Dry

Average fuel moisture content should be less than 15 percent. Slash moisture is usually lowest in the fall.

Apply Liberally

Use very generous applications. Seal large holes and cracks. Priming solution and lumber sealant may be applied with any conventional power sprayer. The use of primer requires petroleum-tolerant gaskets, hoses, and other parts on pumps. Pumps to be used with SS-1 should have gears and impellers that are somewhat worn. Be sure positive displacement pumps have pressure-control devices. Exhaust heat may have to be directed on pump regions of close tolerance (packing gland) when pumping SS-1.

Burn as Soon as Possible

Coatings cracked by sun, wind, or insects will deteriorate. Consequently, it is best to burn as soon as you can do so safely. Burn before precipitation totals 8 to 10 inches. Use ignition aids and fuel boosters, such as petroleum gels, for faster ignition and fire establishment.

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(*Alert Systems*—Continued from page 9)

to the need for the system and its operational steps. They are thoroughly trained in the jobs to which they will be assigned in the system.

A 3-day school is ordinarily sufficient. The first half day is spent in orientation and system concept. The next day and a half are devoted to training in the individual overhead position, bearing down on sound principles of fire organization and management.

The third day comprises testing, group discussion, and simulated fire exercises. Another valuable training session is a postseason review in which forest personnel evaluate the system and suggest improvements.

MOBILIZING THE ALERT

The persons qualified to mobilize the alert, i.e., diagnose a fire as needing a "C" or "D" Alert effort, should be determined at the first planning conference. Usually rangers, assistant rangers, FCO's, and selected, experienced lookouts qualify. Once decided, the information should be publicized within the fire control force, and a check made to see that the persons concerned are made fully aware of their responsibility.

The steps in mobilization are:

1. Qualified officer (ranger, air patrol, lookout, etc.) advises the dispatcher of an Alert fire situation. His message should contain only essential information, e.g.: "Dispatcher, this is Ranger McVey. Scramble Class-C Alert, in Muleshoe Canyon, SW ¼ sec. 22, T. 6 S., R. 4 E.
2. The dispatcher then advises overhead duty roster of the Alert, giving the fire's location, and activates forces based on a material and supply guide form. (Often, many on overhead duty will acknowledge the Alert message and proceed without dispatching.)
3. Duty personnel advise the dispatcher of their ETA at the fire, pick up their kits (or arrange for the kits to be delivered at the fire), and proceed.
4. The air scout gets airborne and over the fire, prepares initial sketch map and polaroid photograph of the fire, and drops them to the fire boss or plans chief, whoever is first at the fire.
5. The fire boss or plans chief advises unarrived duty personnel of the headquarters meeting area, marking it for air observation.
6. The plans chief prepares duplicate sketches from the airdrop map of the fire for line and sector bosses.
7. The fire boss, with the plans chief's aid, evaluates the fire and his resources, orders more men and equipment as needed (or reclassifies the Alert), and rapidly develops an attack plan.
8. Using the plan and maps, a briefing is held with the overhead team, and the fire boss assigns sectors and implements the plan.

With the availability of two types of alert organizations, many combinations are possible. Ordinarily the C-Alert team is mobilized initially, followed by a D-Alert if needed. But on a worse burning day, the D-Alert may be initially mobilized. Furthermore, the acreage figures are only guides. Sometimes the larger D-Alert team might be mobilized for a 15-acre fire, and a C-Alert team for a 5-acre fire. The systems may and probably will be modified in practice. Basically the C-Alert team is one of two sectors, and the D-Alert team is one of three sectors. Since flexibility is important, it is possible to add sectors to either Alert team.

CONCLUSION

The "C" and "D" Alert System is designed for one burning period. If the fire is contained within 24 hours, the system has served its purpose. If not, the relieving team inherits more information and a better organization to build on than is generally the case. In any event, the system provides a preplanned framework, flexible and capable of expansion, to enable the quickest and most effective use of local personnel and material.

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FIRE CONTROL NOTES

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FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

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COVER—This prescribed burning crew is starting a backfire in South Carolina.

(NOTE—Use of trade names is for information purposes and does not imply endorsement by the U.S. Department of Agriculture.)

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PRESCRIBED BURNING TECHNIQUES ON THE NATIONAL FORESTS IN SOUTH CAROLINA[1]

ZEB PALMER and D. D. DEVET[2]

Many prescribed burning effects on National Forest lands are well known. However, little study has been done on burning techniques to achieve specific results under specific conditions of weather, fuel, and topography.

This note will primarily consider the prescribed burning techniques used on the National Forests in South Carolina. Prescribed burning has been used as a management tool for more than 20 years (fig. 1). Fortunately, the even-aged timber management plans for the Forests permitted extensive use of fire. More than 43,000 acres are now prescribe burned annually.

PURPOSE OF PRESCRIBED BURNING

The initial purpose was to reduce fuels to lessen the fire hazard. Later prescribed burning was used in undesirable species control, brown spot disease control, planting site preparation, seedbed preparation, range betterment, and wildlife habitat improvement.

Figure 1.—District Ranger on the Santee Ranger District, Francis Marion National Forest, briefs his crew prior to the start of burning operations.

Burning to improve wildlife habitat is used to obtain specific results such as:

1. Removing leaf and needle litter, which has a smothering effect on desirable forbs and legumes.
2. Stimulating quail indicator species such as Tick Trefoil (Desmodium spp.) and partridge pea (Chamaecrista spp.).
3. Increasing deer browse.
4. Encouraging fruiting of ground oak (Quercus pumila) and huckleberries (Vaccinium spp.).
5. Maintaining openings for deer and turkey.
6. Reducing basal area of noncommercial understory species.

IMPORTANCE OF WEATHER

Burn only if the weather is right. South Carolina weather conditions under which prescribed burning can be conducted follow. These conditions apply to most of the Southeastern United States.

	Winter	*Summer*
Relative humidity (percent)	20-45	20-55
Wind velocity (m.p.h.)	3-10	3-10
Wind direction	(1)	(1)
Temperature range (°F.)	34-75	85-100
Buildup index	3-30	6-40

[1] Any reasonably constant direction is acceptable. The most unreliable wind directions are in the easterly quadrants.

A special fire danger weather station is not necessary. Local weather bureau offices can supply all of the above except the buildup index. Soil moisture conditions must be field checked. There must be a damp humus layer in the A_0 horizon.

FIRING TECHNIQUES

Five firing techniques are now used on the National Forests in South Carolina:

1. Backfire
2. Headstrip
3. Spot or Checkerboard
4. Flank
5. Head Fire

---

[1] This paper was presented by the authors at the Southeastern Wildlife Conference, Tulsa, Okla., on Oct. 11, 1965.

[2] Respectively, District Ranger, Ouachita National Forest, Ark., and Fire Control Staff, National Forests in South Carolina, Columbia, S.C.

These techniques are employed on specific occasions to accomplish specific purposes (fig. 2). Two or more techniques are used for most burns.

Backfire

A baseline is established, and perimeter and interior lines are placed approximately 10 chains apart. There may be plowed lines or natural barriers such as creeks, roads, or swamps. On slopes, the baseline should be the top of the ridge, and the perimeter lines should be on flanks. Interior lines should be as close to the contour as possible. The fire is started on the baseline (fig. 3). After the base is safeguarded, the interior lines are fired.

This method is employed in slope burning and burning in relatively young timber stands, and results in a minimum of scorch. It is recommended for prescribed burning beginners.

The method works well with heavy fuel, gives a minimum of scorch, provides heat at ground line for the longest periods, and is recommended for summer burning when there are high temperatures, heavy fuels, low relative humidities, strong winds, and high fire dangers. This method is the most popular, easiest to apply, and fastest.

However, this method needs steady wind from a constant direction, plenty of time, interior lines prepared in advance, and continuous and uniform fuels (at least 1 ton per acre of fuel).

Headstrip

Short head fires are run with the wind into a prepared baseline or burned area. The strips will vary in width, depending upon density and distribution of fuel. This technique is combined with a backing fire to initially secure the baseline. After the base is secured, strip burning is begun.

Figure 2.—Prescribed burning crew watches small test fire to see if it is burning according to the weather forecast.

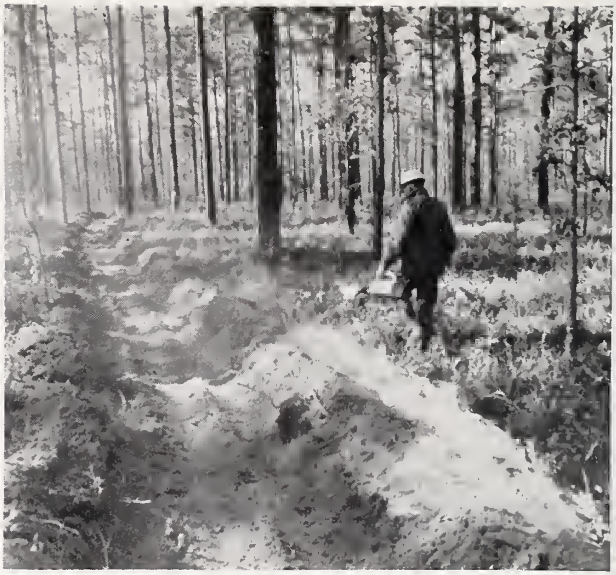

Figure 3.—Backing fire is started along the plowed line used as a base of operations.

This technique can be conducted when relative humidity is 50 to 55 percent, has flexibility for wind direction changes, can be conducted in scattered, light fuels, needs minimum preparation, is relatively inexpensive, is cheaper because few plowed lines are required, and is rapid.

Spot or Checkerboard

This technique is also called "area ignition." A series of small spot fires are uniformly distributed so all spots converge before any one spot can gain momentum. Possible damage to residual stands is least for closest spots.

A skilled crew familiar with fire behavior and burning objectives is required.

This technique should be used primarily for winter burning at low air temperatures. It can also be used when conditions are too hot for headstrip burning.

Flank Fire

A fire that spreads perpendicularly to the prevailing wind is started. The line of fire is started directly into the wind (fig. 4). The fire then spreads laterally at right angles to the established line. This technique is frequently used to secure the edges of the prescribed burn when a backfire, strip head, or checkerboard fire progresses.

Flanking is the cheapest and fastest burning procedure.

This method requires a steady wind, uniform and preferably light fuels, and a trained crew.

(Continued on page 14)

PRESCRIBED BURNING TO REDUCE KUDZU FIRE HAZARD

Marlin H. Bruner, *Associate Professor,*
Forestry Department, Clemson University

Fire control men with experience in the South are aware of the problem caused by kudzu (*Pueraria thunbergiana* (S. & Z.) Benth.) in fire suppression.

This vine, introduced from Asia more than a century ago for ornamental purposes, and widely planted since the midthirties for erosion control, is now a common plant along many railroads and highways in the South. To the casual observer, the lush, green kudzu is only a vine adorning the roadside.

However, as fire control men who have worked in the South realize, this seemingly harmless plant changes drastically with the first killing frost. Its withered, dry leaves and vines are transformed into flashy fuels that provide a most effective bridge for carrying fires from rights-of-way to adjacent fields and woods. Fire suppression in kudzu is almost impossible without abundant water—the fires explode, and the entanglement of vines, stolons, and roots preclude the use of fire rakes and plows. Firefighting in kudzu is a difficult task, indeed!

On the Clemson Forest, managed by the Forestry Department of Clemson University, kudzu causes a fire hazard along 3 miles of railway right-of-way. Before control measures were initiated, fires started on this stretch during the dormant season and frequently entered the forest by means of the kudzu bridge.

Three years ago, with the approval of the railroad's district engineer, annual prescribed burning was begun. The following method is successfully employed:

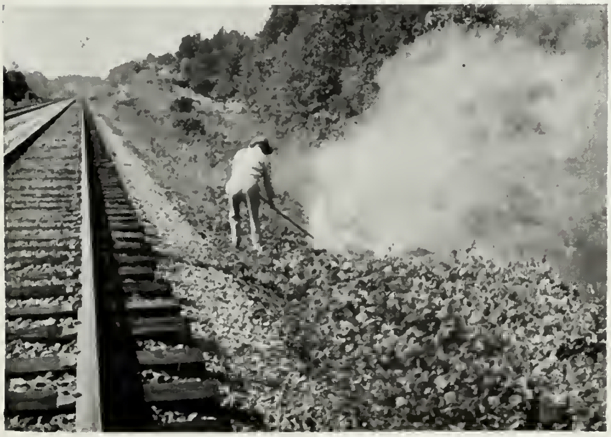

Figure 1.—Burning a kudzu strip previously killed by 2, 4, 5-T spray.

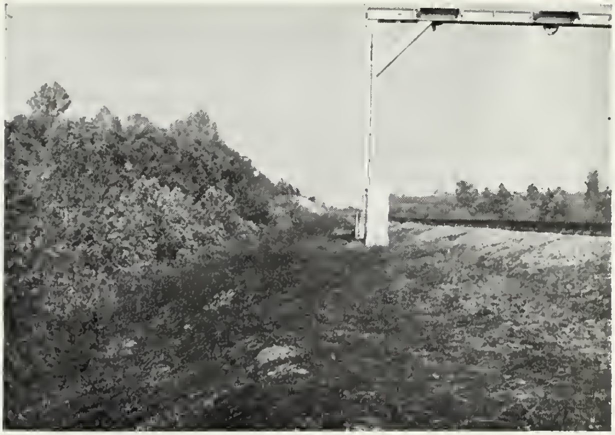

Figure 2.—Kudzu fire hazard has been reduced along railroad right-of-way by applying 2, 4, 5-T and then burning the vines.

1. During mid-August a strip of kudzu, about 20 feet wide, is sprayed along the right-of-way. A mist blower is used to apply a mixture of 5 gallons of 2, 4, 5-T (4 pounds acid equivalent per gallon), 5 gallons of fuel oil, and 20 gallons of water. Other formulations might yield equally good results.[1]

2. The kudzu is burned approximately 2 to 3 weeks later, after it has died and when good burning conditions prevail (fig. 1). The sprayed strip burns cleanly (fig. 2), and the fire dies or is easily controlled when it moves into the green, unsprayed vines, which serve as firebreaks before the first killing frost.

The total annual cost is about $30 a mile. Thus, a serious fire hazard of the Clemson Forest has been nearly eliminated, easily and inexpensively, by spraying and burning. Perhaps this procedure or a modified one will be useful for other persons confronted with a similar problem.

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[1] All chemical compounds should be used only when needed and should be applied with caution.

A FIRE-BEHAVIOR TEAM FIELD UNIT

JOHN D. DELL, *Fire Research Technician, and* MELVIN K. HULL, *Meteorologist,*
Pacific Southwest Forest and Range Experiment Station

Fire-behavior officers from the Riverside Forest Fire Laboratory (in California) are finding that a team apporach to the fire-behavior job increases their effectiveness in serving the fire-control organization.[1] [2] The fire-behavior team consists of two or three men. It makes frequent observations of weather, fuels, and topography in the fire area and reports findings to the fire-behavior officer.

Team members require much specialized equipment (see equipment checklist).

To increase team efficiency in field operations, a small fireclimate survey trailer has been converted for use as a field equipment trailer. The unit, designed and outfitted by the authors, is kept at the fire laboratory. Ready for immediate call, it contains all the supplies and equipment required by a fire-behavior team on a major wildfire (fig. 1).

It costs about $650 to equip the trailer. There are additional costs for backpack radios or a theodolite and tripod. The theodolite equipment, purchased commercially, costs about $1,500. This equipment occasionally is available from military surplus.

EQUIPMENT CHECKLIST FOR FIRE-BEHAVIOR TEAM UNITS

Items for Ground Observations and Upper Air Soundings

3	Kits, weather belt, w/sling psychrometer, wind meter, water container, compass, notebook, and RH and DP tables.

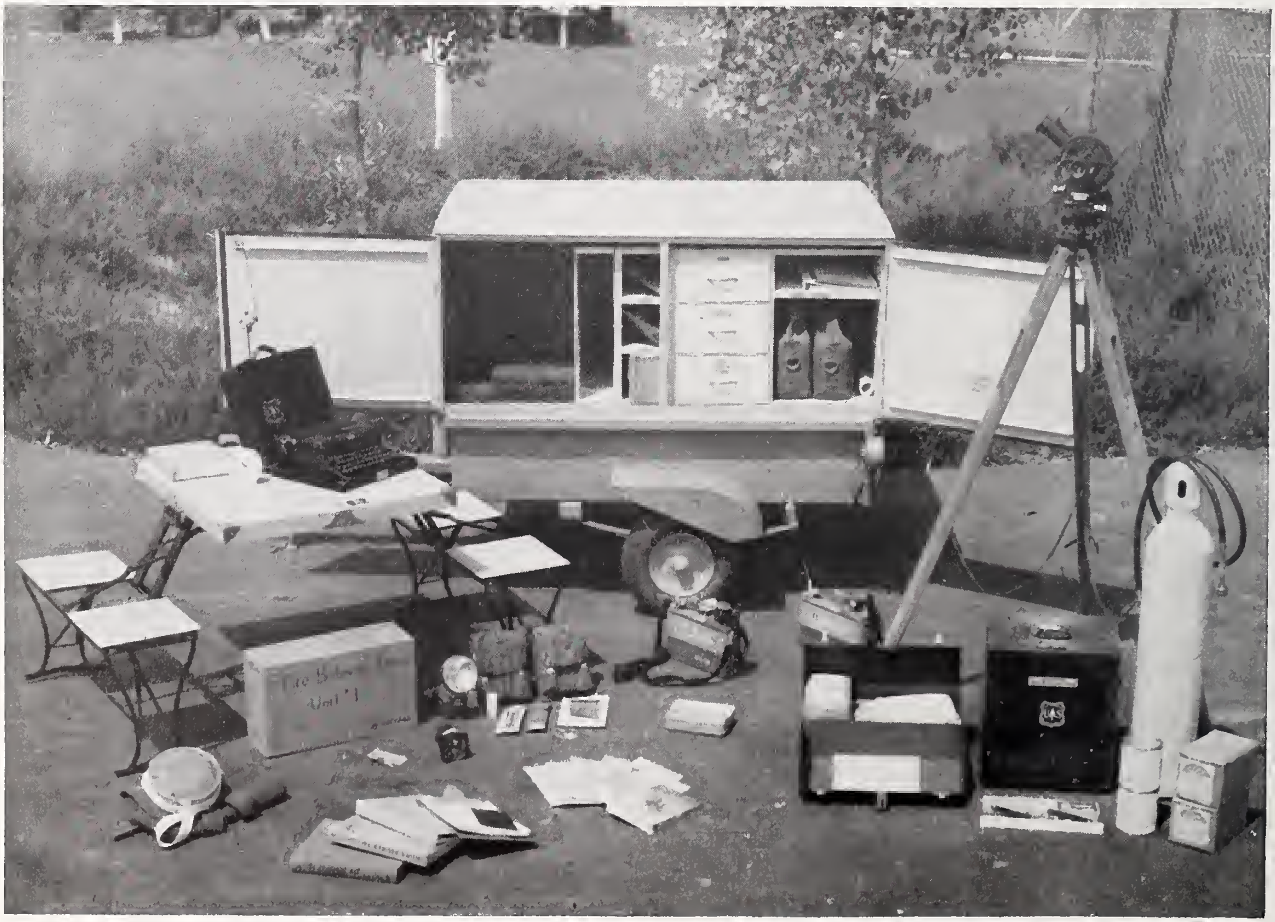

Figure 1.—Components of the field unit include equipment for ground and winds aloft observations and upper air soundings.

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[1] Countryman, C. M., and Chandler, C. C. The fire behavior team approach in fire control. Fire Control Notes 24(3): 50-60. 1963.

[2] Dell, J. D. The fire behavior team in action—the Coyote Fire, 1964. Fire Control Notes 27(1): 8-10, 15. 1966.

2	Fuel moisture sticks
1	Scale, fuel moisture, portable
1	Altimeter
1	Fuel type guide, w/photos
1	Computer, forward rate of fire spread (R-5 Model 48)
25	Diagrams, pseudo-adiabatic
1	Hygrothermograph, w/shelter

Items for Winds Aloft Observations

1	Kit, pibal, including the following:
1	Theodolite, w/batteries
1	Tripod
3	Balloons, pibal (white, black, and red), box
50	Parachutes, pibal
60	Lights, pibal
1	Roll of string
1	Box of rubberbands
1	Container, water, plastic
2	Flashlights
2	Wrenches, crescent and Allen
2	Helium tanks, *full*
1	Regulator, helium tank, w/rubber hose
1	Balance, nozzle, w/base
1	Clipboard
200	Computation sheets, winds aloft[1]
1	Table, horizontal distance[1]
200	Charts, wind evaluation (11 by 17 inches)[1]
1	Scale, engineers, drafting, triangular (scales: 10 to 60)
1	Parallel rule

Items for Communication

2	Radios, backpack
1	Radio, portable, w/longwave band (for aviation weather broadcasts)

Miscellaneous Items

1	Table, folding, w/four seats
1	Clock, alarm
1	Lantern, electric, portable
1	Pair of binoculars
1	Knapsack
1	Case of emergency rations
1	Canteen
1	Set of keys, gate
1	Camera, Polaroid, w/film
1	Set of maps (forest, county, and topographic)
1	Set preattack block books (if available)
1	Fireline notebook
1	Kit, first aid and snakebite
6	Notebooks, field, pocket
1	Typewriter, portable
1	Package of paper, typing
1	Package of paper, carbon
25	Envelopes, filing, 9½ by 12 inches
2	Note paper pads
1	List, Region 5 fire weather stations
1	Instruction book

[1] These items are specially designed forms to evaluate winds aloft in the field, and will be further described by Melvin K. Hull in a separate report.

REGION 3 INSPECTION OF INTERNAL COMBUSTION ENGINES

Division of Fire Control

Region 3[1] has had some disastrous fires caused by faulty internal combustion engines. Greater use of National Forests by contractors, special-use permittees, and others has made a more rigid inspection system for internal combustion engines imperative. Equipment inspections have been mandatory for timber sales, contracts and permits, and Forest Service equipment. However, a method to identify inspected equipment had not been established, so control was inadequate.

A strong inspection program has several facets:

1. It covers tractors, loaders, trucks, pickups, powersaws, etc., and also all equipment used off surfaced roads in hazardous areas.
2. It enables each user of this equipment to understand the program, including its purpose and operation. It should also inform him of his responsibility to protect his equipment from fire.
3. It provides the Forest officer with proof of inspection. If equipment failed the inspection or had not been inspected, it could not be operated on the Forest.

The program was inaugurated in 1964. First, we developed an inspection form. The inspection covered spark arresters, mufflers, and exhaust systems. All previously inspected equipment had to be inspected in April, May, June, and July—the critical fire months for the Region. Uninspected equipment had to be inspected prior to use on the Forest. An inspection sticker was placed on approved equipment in a conspicuous place. The stickers for the four months had different colors. The July sticker, which was white, indicated approval until the next April.

In 1964, we significantly reduced fires resulting from internal combustion engines. We have reviewed the comments from designated Forests and have modified and planned our program as follows:

1. Our inspection form (fig. 1) has been revised.
2. All equipment without a previous formal inspection will be inspected before it enters the

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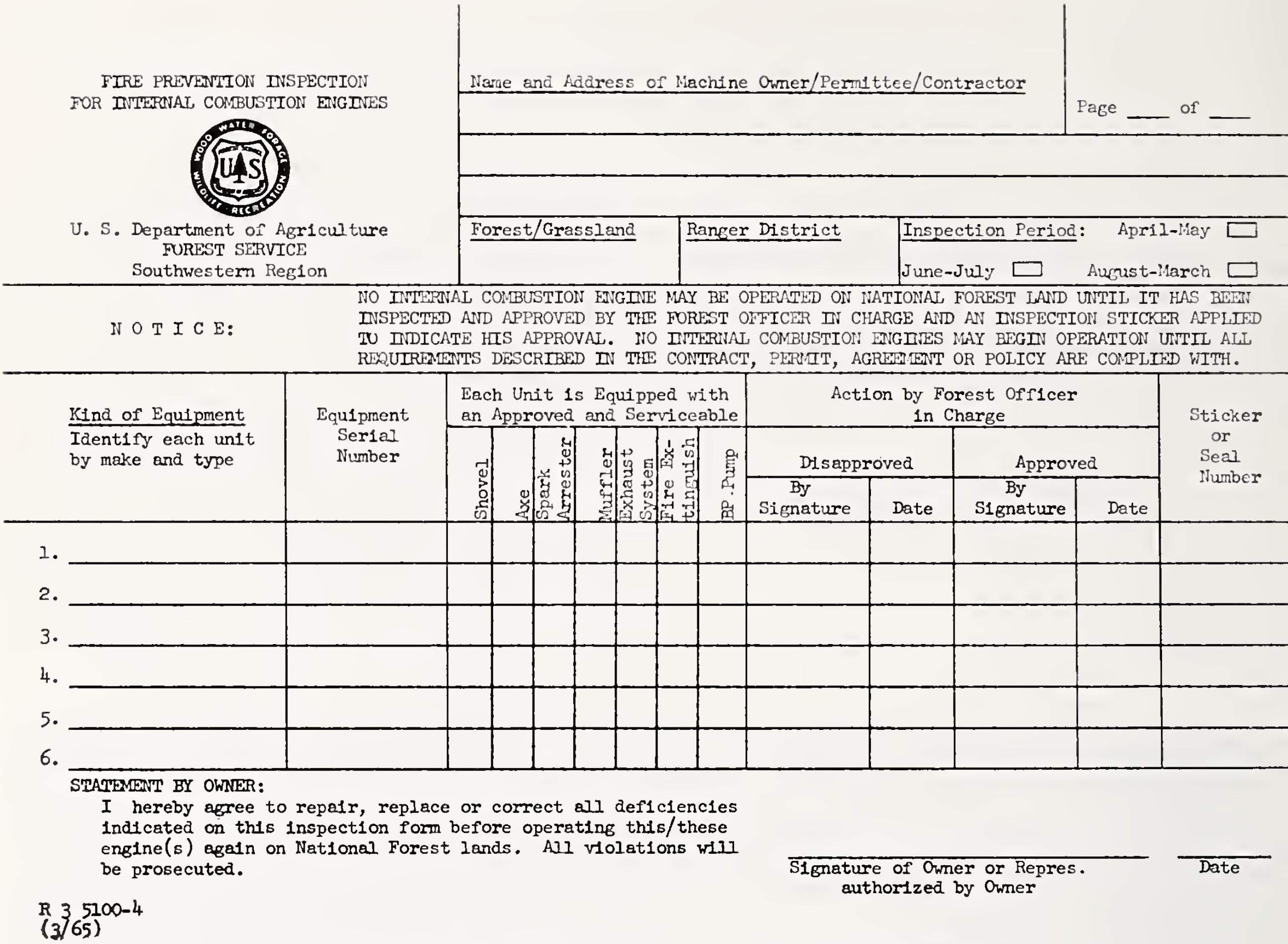
[1] Region 3 (Southwestern Region) consists of Arizona and New Mexico.



FIRE PREVENTION INSPECTION
FOR INTERNAL COMBUSTION ENGINES

U. S. Department of Agriculture
FOREST SERVICE
Southwestern Region

Name and Address of Machine Owner/Permittee/Contractor

Page ___ of ___

Forest/Grassland	Ranger District	Inspection Period: April-May ☐ June-July ☐ August-March ☐

NOTICE: NO INTERNAL COMBUSTION ENGINE MAY BE OPERATED ON NATIONAL FOREST LAND UNTIL IT HAS BEEN INSPECTED AND APPROVED BY THE FOREST OFFICER IN CHARGE AND AN INSPECTION STICKER APPLIED TO INDICATE HIS APPROVAL. NO INTERNAL COMBUSTION ENGINES MAY BEGIN OPERATION UNTIL ALL REQUIREMENTS DESCRIBED IN THE CONTRACT, PERMIT, AGREEMENT OR POLICY ARE COMPLIED WITH.

Kind of Equipment Identify each unit by make and type	Equipment Serial Number	Each Unit is Equipped with an Approved and Serviceable							Action by Forest Officer in Charge				Sticker or Seal Number
									Disapproved		Approved		
		Shovel	Axe	Spark Arrester	Muffler	Exhaust System	Fire Extinguish	BP.Pump	By Signature	Date	By Signature	Date	
1.													
2.													
3.													
4.													
5.													
6.													

STATEMENT BY OWNER:
I hereby agree to repair, replace or correct all deficiencies indicated on this inspection form before operating this/these engine(s) again on National Forest lands. All violations will be prosecuted.

Signature of Owner or Repres. authorized by Owner

Date

R 3 5100-4
(3/65)

Figure 1.—This is the inspection form for internal combustion engines.

woods. Inspected equipment is formally inspected twice a year, in March and May. The March sticker, which is green, is good until May 31; the May sticker, which is red, is accepted until July 31. A white sticker will be placed on equipment inspected from August through February.

3. The type of equipment and class of users are (minimum):

A. Internal combustion engines on timber sale areas.

B. Forest Service internal combustion engines, including GSA equipment and leased or rented private equipment.

C. Any permitted user where powersaws are used. This includes free use[2] because free-use permittees often obtain wood from old timber sale areas. (The powersaw sticker is of special material because of grease.)

D. Contractors of roads or those doing construction work in connection with special uses.

There will be no attempt to inspect grazing permittee pickups or trucks. However, their powersaws will be inspected. Hunters, fishermen, tourists, and those seeking recreation are not required to have inspection stickers.

---

[2] Usually permitted removal without charge of dead or dying timber by qualified individuals for personal use.

CAMERA GUNSTOCK MOUNT

Roland J. Treubig, *Forester,*
Louisiana Forestry Commission

A tripod is usually needed to steady the telephoto lenses of a camera; however, the standard tripod is generally quite cumbersome. The gunstock mount shown in figure 1 is a very convenient and portable substitute.

The gunstock mount is made of 5-8-inch exterior-grade plywood. A 1- by 1-inch hole is drilled from one corner of a 3- by

(Continued on page 16)

SCHEDULING AIRCRAFT FOR FOREST FIRE DETECTION

P. H. Kourtz, *Fire Research Officer, Canadian Department of Forestry*

The objective of all detection systems is to minimize the acreage burned prior to detection. Forest protection organizations, which continually try to improve their detection systems, are relying more and more on aircraft. In part of Canada, aircraft alone are used to detect fires; however, in most areas they supplement tower networks.

When only aircraft are used, no point in the forest is constantly watched. However, by determining the time required for planes to patrol given areas and the rate of fire spread from ignition to detection, the area burned prior to detection can be estimated. Under these conditions, to minimize burned areas, two questions must be answered. First, how many patrols should be made each day? Second, at what time should they be made? The number of patrols required each day varies with the number and rate of spread of expected fires. The time for patrols depends on the distribution of fires throughout the day; more fires are detected in the afternoon.

In Canada, the fire danger rating system developed by the Department of Forestry permits an estimate of the potential number of fires and their probable rate of spread. Rates of fire spread for various danger index classes were taken from Beall (1950).[1]

Danger index class	*Rate of perimeter spread (yd./hr.)*
Extreme	440
Moderate	365
Low	263

The rates, based on many 1938–46 New Brunswick fires, were averages for all fuels, times of day, and months of fire season.

To begin this analysis, it was first assumed that each air patrol covered 100 percent of the patrol area and that there was an equal chance of fire occurring in any place on the area. It was also assumed that there was an aircraft and pilot available at the specified patrol times and that he was able to detect all fires in the patrol area. For this analysis rates of spread for uncontrolled fires are required. Barrows (1951)[2] found that the average rate of spread from discovery to attack for uncontrolled fires burning in "High" fuels with a burning index of 70 was 293 yards of perimeter increase per hour. He stated that above-average rates of spread will occur in "High" fuels if the fires are spotting ahead. Eighty-five percent of the fires burning in "High" fuels with a burning index of 70 had a maximum rate of spread of 616 yards of perimeter increase per hour. Thus, the New Brunswick figure of 440 yards for the Extreme danger class was between the average and maximum values given by Barrows (1951). However, he found the maximum rate of spread was 143 yards of perimeter increase per hour for "High" fuels with a burning index of 20. The New Brunswick rate for the Low danger class was 263 yards per hour; this figure is above the average rate of fire spread for that danger class.

For this analysis, the rates of perimeter increase were converted to rates of acreage increase by the following formula (Hornby 1936):[3]

$$A = \frac{7.3\,P^2}{1{,}000}$$

where P = perimeter in yards and
A = area in acres

This formula assumes that the fire increases in an oval shape where P is 1½ times the circumference of a circle of equal area.

The number of fires occurring each hour of the day was determined first for each danger index class from many 1938–51 New Brunswick fires, and second, for the combined danger index classes using a report by Beall and Lowe (1950).[4] While a large sample of fires was used, the division of the sample into four dangers classes did not provide enough fires to give a reliable occurrence and time-frequency curve. Therefore, the analysis was based on the occurrence times determined for the combined danger index classes.

Using data available on the occurrence and rate of spread of fires in New Brunswick, various air patrol times were simulated for each danger index class. By knowing the corresponding rate of fire spread, the distribution of fires throughout the day, and the time between the earliest detectable time and the time of the air patrol, the sizes of the fires at the time of the patrol were determined. It was assumed that fires could be detected during daylight and that the fires did not spread during 8 night hours. The areas burned at the time of the air patrol were weighted by their corresponding occurrence frequencies. The total weighted areas burned for various patrol times and danger index classes are shown in table 1. A single patrol at 5:30 p.m. produces the lowest total weighted area burned for all three danger index class days. The weighted area burned during Extreme danger, as seen from a 5:30 p.m. patrol, is shown in table 2. The totals of the weighted areas burned were found for many patrol times, and the one that resulted in the lowest total was considered optimum. The effect of more than one patrol per day for the Extreme danger class was shown in table 3. Therefore, use of 1:30 p.m. and 6:30 p.m. patrols minimized the total weighted area burned. One to five patrols were simulated for the Extreme danger class (table 4). Each additional patrol reduced the total weighted area burned by approximately 50 percent.

---

[1] Beall, H. W. 1950. Forest fires and the danger index in New Brunswick. Forest Chron. 26:2.

[2] Barrows, J. S. 1951. Forest fires in the Rocky Mountains, U. S. Forest Service. North. Rocky Mountain Forest and Range Exp. Sta. USDA Pap. 28.

[3] Hornby, L. G. 1936. Fire control planning in the North. Rocky Mountain Forest and Range Exp. Sta. USDA Progr. Rep. 1.

[4] Beall, H. W., and Lowe, C. J. 1950. Forest fires in New Brunswick 1938-1946. Canada Dep. Resources and Develop. Forest Fire Res. Note 15.

TABLE 1.—*Total weighted areas burned for various patrol times and danger index classes*

Patrol time (one per day)	Low danger	Moderate danger	Extreme danger
	Acres	*Acres*	*Acres*
8:30 a.m.	5,404	10,398	15,106
10:30 a.m.	5,515	12,170	17,654
12:30 p.m.	5,701	10,792	15,689
1:30 p.m.	4,596	8,656	12,605
2:30 p.m.	3,338	6,273	9,154
3:30 p.m.	2,310	4,360	6,359
4:30 p.m.	1,857	3,516	4,790
5:30 p.m.	*1,665*	*3,176*	*4,639*
6:30 p.m.	1,787	3,429	4,679
7:30 p.m.	2,142	4,118	5,241

TABLE 2.—*Weighted area burned at time of a 5:30 p.m. patrol during Extreme danger (rate of perimeter increase—440 yards per hour)*

Time	Elapsed times to 5:30 p.m. patrol	Fire perimeter at patrol time	Fire area at patrol time	Number of fires starting	Weighted area
	Hours	*Yards*	*Acres*	*Percent*	*Acres*
7– 8 a.m.	10	4,400	144	0.6	86
8– 9 a.m.	9	3,960	115	1.8	207
9–10 a.m.	8	3,520	91	3.6	328
10–11 a.m.	7	3,080	70	5.5	385
11 a.m.–noon	6	2,640	51	8.5	434
noon–1 p.m.	5	2,200	36	13.3	478
1– 2 p.m.	4	1,760	23	15.8	363
2– 3 p.m.	3	1,320	13	15.7	204
3– 4 p.m.	2	880	6	12.7	72
4– 5 p.m.	1	440	1	7.5	11
5– 6 p.m.	0	0	0	5.3	0
6– 7 p.m.	23	6,600	311	3.0	933
7– 8 p.m.	22	6,160	273	1.6	437
8– 9 p.m.	21	5,720	239	1.7	406
9–10 p.m.	20	5,280	204	.6	123
10–11 p.m.	19	4,840	171	1.0	171
Total	----	----	----	----	4,639

Table 3.—*Effect of two patrols per day for Extreme danger class*

Time of two patrols (p.m.)	Weighted areas burned
	Acres
2:30, 6:30	1,494
1:30, 6:30	*1,445*
12:30, 6:30	1,831
1:30, 5:30	1,669
1:30, 7:30	1,628

The previous totals of weighted areas burned were found by assuming 100 fires occurred each day regardless of the level of the burning index. However, a New Brunswick study by Beall (1950) revealed the rates shown in table 5.

By knowing these occurrence rates, the danger index class, and an acceptable level of burned area, the optimum number of patrols during each danger class day could be approximated. The level of the total of the weighted areas burned which could be tolerated was chosen as the minimum that resulted from one daily patrol during a Moderate danger period (3,176 as shown in table 1). Therefore, the total of weighted areas burned on all days regardless of the danger index must be almost as low as or lower than this figure.

Table 4.—*Effect of additional patrols for Extreme danger class on weighted areas burned*

Number and optimum time of patrols	Weighted areas burned
	Acres
1— 5:30 p.m.	4,639
2— 1:30 p.m., 6:30 p.m.	1,445
3—10:30 a.m., 3:30 p.m., 7:30 p.m.	817
4—11:30 a.m., 2:30 p.m., 4:30 p.m., 7:30 p.m.	405
5— 6:30 a.m., 12:30 p.m., 2:30 p.m., 4:30 p.m., 7:30 p.m.	189

Because five fires were expected on each Extreme day and only one fire on a Moderate day, the totals of the weighted areas burned for each Extreme day must be one-fifth that of a Moderate day (3,176 ÷ 5 = 635). During the Extreme period three patrols will bring the total of the weighted areas burned to 817, and four patrols will reduce it to 405 (table 4). Therefore, there must be at least three patrols on Extreme days so there is approximately the same total of weighted areas burned as with one patrol on a Moderate day.

Table 5.—*Average rates of fire occurrence for various danger index classes*

Danger index class	Average rate of fire occurrence
Low	1 per 7 days
Moderate	1 per day
High	2 per day
Extreme	5 per day

Many personnel believe that single daily air patrols should be flown at 2 p.m. because the largest number of fires are discovered then. The fires which have ignited that day would be detected when most are very small. However, many fires ignite after 2 p.m., especially between 2 p.m. and 8 p.m., and these fires will be very large by 2 p.m. the next day. Therefore, single air patrols should be flown so that the total weighted area burned will be minimized. As this analysis indicated, this time is well past the peak of the occurrence time-frequency curve.

There are several weaknesses in this analysis. First, while knowledge of the earliest times that an aircraft could discover the fires was required, the starting times of fires were used. However, fires cannot be detected as soon as they start. Second, more fire reports would be required in order to classify discovery times by danger index classes. If the sample had been large enough, the distribution of discovery times should have approached a smooth curve since conditions favorable for burning usually improve during the morning, peak in the midafternoon, and decline during the evening. Third, it was assumed that fires did not spread for 8 hours during the night. Such an assumption appears wrong because an average rate of spread was used. However, the rate of spread was determined for many fires, many of which were extinguished on the same day they were discovered. To determine the effect of the length of time of no fire spread on the patrol time, it was assumed that the fire spread at the same rate during the night and the day. For the Extreme danger class, the optimum patrol time was now 7 p.m. Therefore, the number of hours that the fire is assumed to not

(Continued on page 14)

NIGHT HELICOPTER USE IN FIRE CONTROL

Division of Fire Control, Washington Office

Small helicopters will probably soon be operational at night on forest fires. This assertion is based on the results of 3 years of tests and development work at the Missoula Equipment Development Center and the Pacific Southwest Forest and Range Experiment Station.

By using helicopters at night, advantage can be obtained from the following:

1. Reduced fire intensity and rate of spread.
2. Cooler temperatures, lower densities (at given altitudes), and greater air stability.
3. Less competition for airspace from air tankers, smokejumpers, and cargo airplanes.

With round-the-clock operations, more dependence can be placed on the helicopter. As experience is gained in night operations, duplicate systems for moving manpower and equipment and for scouting will become less necessary.

1963-65 TESTS

Before 1963, helicopters had been used for only a few night flights involving extreme firefighter emergencies. In 1963, the Missoula Equipment Development Center started preliminary studies to determine the feasibility of night helicopter operations for forest fire control. First, military use of helicopters at night was investigated. Nearly all military operations involve large helicopters capable of carrying expensive and sophisticated navigational instruments. It was not feasible or practical to install this type of equipment in the small helicopters commonly used in Forest Service operations. Next, the commercial market was surveyed for efficient lighting and navigational equipment. Several types of equipment were obtained and evaluated during a series of preliminary flights in 1964. Much was learned about pilot technique as well as about equipment. Techniques were refined as experience was gained. Equipment was replaced as improved types were obtained and evaluated. Based on 1965 tests in Montana and southern California, the following general tentative requirements and guidelines were developed.

REQUIREMENTS AND GUIDELINES

Pilot Qualifications and Training

A pilot must be willing and interested in night helicopter flying. Qualifications must be more stringent than for daylight helicopter operations. Pilots selected must receive necessary training in procedures and use of equipment for safe route finding and flight.

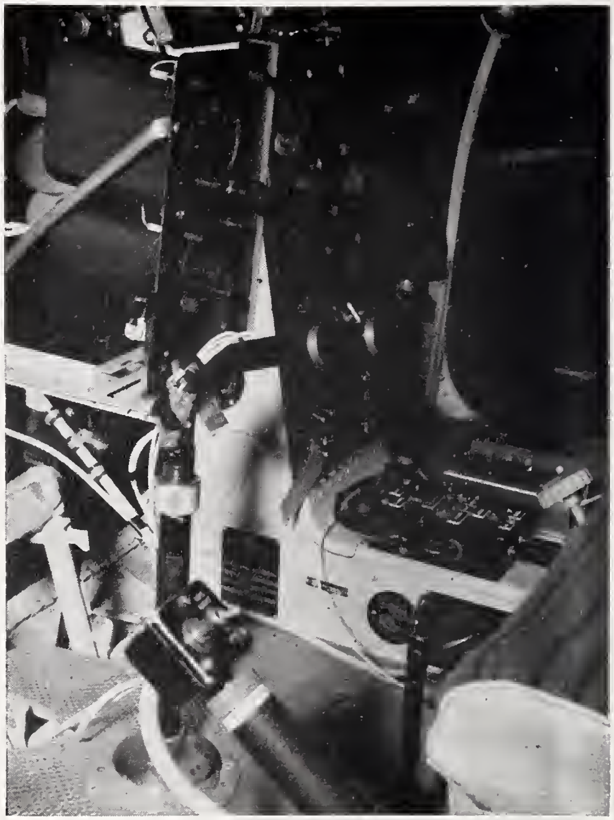


Figure 1.—Special instruments that were installed.

Helicopters

Newer helicopters with improved performance are essential because they provide a greater safety margin. The following special aircraft accessory equipment (fig. 1) also is necessary:

1. Controllable searchlight
2. Air-net radio
3. Altitude gyro (electric)
4. Directional gyro (electric)

A new lightweight, low-cost radar altimeter tested in 1965 probably has merit.

Helispots

The pad clearing should be a rectangle at least 100 feet wide and 100-200 feet long (fig. 2). Helispot boundaries should be marked with amber lights about a chain apart. When a big field or meadow is used, amber boundary lights are not needed around the entire spot. A green or blue light should indicate the center of the pad.

Helispots should be located so the best terrain can be used for flight routes. Special consideration must also be given to prevailing winds, smoke, and special obstacles or hazards. Specific guidelines for locating helispots in relation to flight routes cannot be given because many factors are involved.

A kit (fig. 3) for marking helispots and for communication with the pilot is essential. For a typical operation, it should include the following items:

1. 5 route marker strobe lights
2. 14 route marker (amber lens) lights
3. 16 emergency landing area marker lights
4. 30 6-volt dry cell batteries
5. 6 5-foot-diameter parachutes
6. 1 air-net radio

Equipment for each spot can be packaged into one or two fiberboard boxes for delivery by parachute, helicopter, or ground vehicle.

Obstacle lights should be used to illuminate hazardous snags, trees along the spot border, or other items that might interfere with flight. These lights should be pointed upward to illuminate the main rotor tips while the helicopter is on the pad. Green or blue lights should be used to mark approaches or turning points; recommendations of the pilot should be followed.

Wind direction is indicated with a lighted "U" or "T". Flashlights attached to white, translucent plastic golf club protector tubes are excellent. These are easily repositioned with changes in wind. Systems which are difficult to reposition should be avoided.

Flight Routes and Emergency Landing Areas

Flight routes must be selected by the pilot and flown during daylight. The routes, which are marked with beacons, should be over terrain with the best emergency landing areas. Each area is marked with one or more lights of a different color. Distances *between* helispots must be as short as possible.

Figure 2.—A helicopter hovers above a helispot.

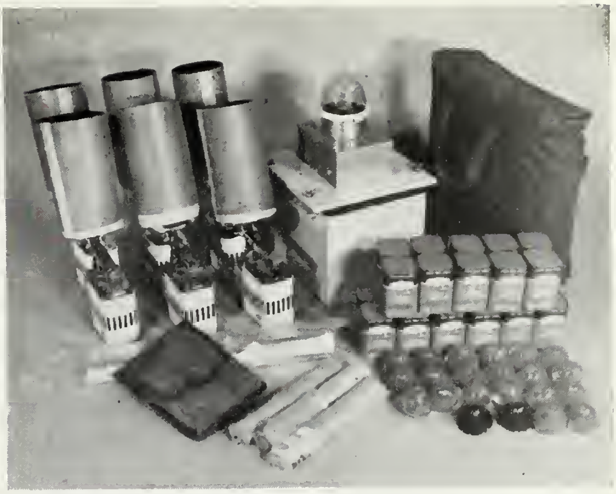


Figure 3.—Helispot marking kit used in these studies.

Visibility

Many interrelated factors affect visibility; these include weather, topography, vegetative cover, moonlight, and smoke. Visibility of ground references can be enhanced by locating helispots and flight routes so that smoke and dark canyons are avoided. Light-colored soil, rocks, vegetation, and cultural features such as roads provide ground references.

Clear skies usually provide optimum visibility and air stability. However, the amount of moonlight seemed to affect night visibility more than cloud cover.

Terrain

If visibility and weather are favorable, terrain usually will not restrict flying when flight routes and helispots are carefully planned.

Physiological Factors

The studies conducted in southern California in 1965 by the Pacific Southwest Forest and Range Experiment Station included physiological phenomenon affecting night flights. Night vision, illusions of vision, autokinesis (apparent but false movement of a light), flicker, and motion vertigo were studied in connection with night flying. These research and flight tests were closely coordinated with helicopter guidance studies conducted earlier by the Missoula Equipment Development Center.

SUMMARY

While flying is more hazardous at night, results of these studies indicate that night flying can be done safely under favorable environmental conditions by using well-trained and qualified personnel, special guidance equipment, and careful planning. However, more information on many phases of night operations must be obtained and analyzed before regular night helicopter flights will be approved for the U.S. Forest Service. Plans are being developed for limited field tests under fire conditions during the 1966 season. These and later tests may prove another valuable application of helicopters in firefighting.

Prescribed Burning—*Continued from page 4*

Head Fire

The head fire is employed on special occasions. The fire is permitted to run with the wind into a prepared firebreak that will stop the spread. This is a dangerous and specialized method employed primarily to kill all aerial vegetation. This technique is used to maintain a wildlife opening under certain conditions, and in brownspot disease control. It is also used when a hot, fast fire is needed.

If not carefully used, this technique could result in a wildfire with spotting, crowning, and other undesirable characteristics.

SUMMARY

Five basic firing techniques are employed for prescribed burning on the National Forests in South Carolina. One technique or a combination of techniques is best under certain conditions of fuel, weather, and topography.

Prescribed burning requires experience and knowledge of fire behavior. All personnel using prescribed burning should recognize the constructive and destructive power of fire.

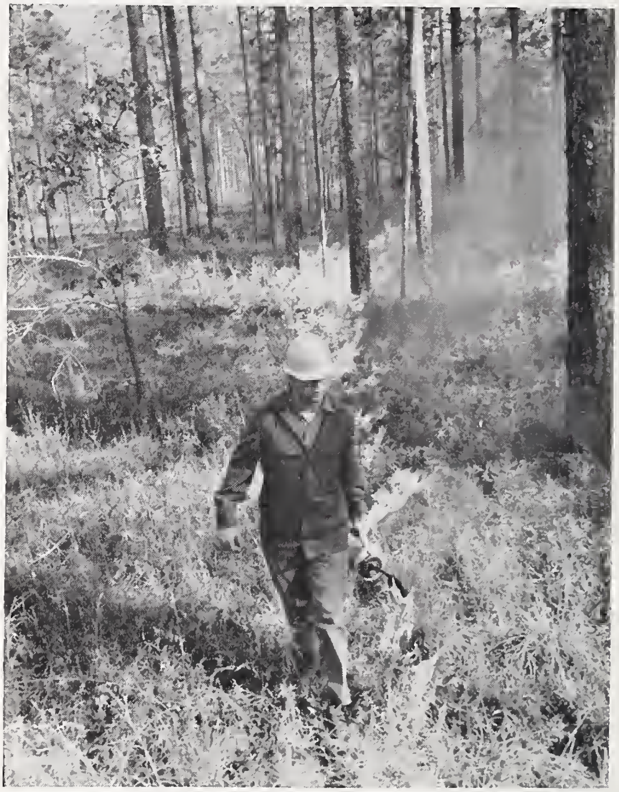


Figure 4.—Flank fire is started with a backfiring torch by a crewman walking directly into the wind.

Scheduling Aircraft—*Continued from page 11*

spread is not critical in determining the time of the air patrol; however, it does greatly influence the total of the weighted areas burned and, thus, the number of patrols required each day.

The rates of spread of fires vary throughout the day. The average rates of spread used in this example were determined from fires burning under all conditions at all times during the day. The accuracy of the analysis may not have been reduced because it was assumed that fires started during all daylight hours. Therefore, the rate of spread has little effect on determining the best patrol time, but it has been shown that rate of spread greatly affects the number of patrols required each day. The main factor influencing the patrol time is the distribution of the discovery times throughout the day.

This method of analysis could be applied locally if there were sufficient data to draw smooth occurrence and time-frequency curves for each danger index class. An average rate of spread for each danger index could either be determined from many local fire reports or could be determined from a study such as that of Barrows (1951). This technique will become more useful in the future, when rates of spread for many types of conditions can be predicted more accurately.

LOS ANGELES COUNTY DEVELOPS NEW CONSTANT-SPEED ALTERNATOR

FRANK HAMP, *Battalion Chief and Equipment Development Officer, Los Angeles County Fire Department*

Editor's Note: Tests conducted by the San Dimas Equipment Development Center show that truck engine heat significantly reduces voltage output of an alternator. This reduction could be critical where voltage must be maintained for efficient operation. The Development Center has recommended field coil modifications to overcome the heat problem. Agencies considering installation of alternators should write directly to the Development Center to obtain further information.

After the Bel Air fire of 1961, the Los Angeles County Board of Supervisors ordered Fire Chief Keith E. Klinger to investigate the possibility of developing a small pump for drafting water from swimming pools. Klinger delegated this assignment to the author. Klinger had remarked that on several major watershed fires millions of gallons of water in swimming pools had not been used—mainly because of inaccessibility to heavy fire equipment. The department has a map of all swimming pools in the area it protects.

The author consulted personnel of Prosser Industries, Inc., Anaheim, Calif. A small, lightweight, portable pump was being marketed, but it required 115 volts of a.c. current at 60 cycles. After 2 years of intensive research, a suitable alternator has been developed for operation by mounting on fleet vehicles where remote operation of electrical equipment requiring domestic a.c. power is desired. It uses a series of automatically variable-speed pulleys that maintain a constant speed.

The first installation of the alternator and pump was made on patrol 82 (fig. 1), which is in the La Canada area.

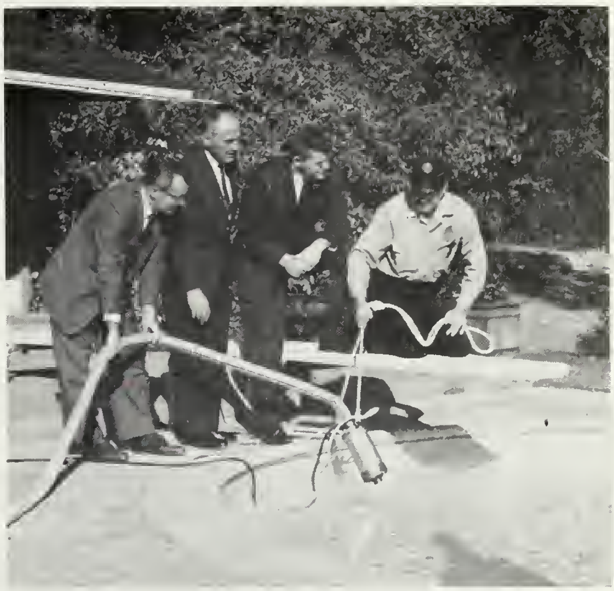


Figure 1.—Electric pump is being submerged in swimming pool.

Twenty-seven patrols are now equipped. These patrols are the first to be equipped because they are more mobile and can move closer to pools.

During the Verdugo Hills fire in March 1964, when the new equipment received its first operational test, it proved very effective. Many firefighting experts predict that all fire apparatus will soon be equipped with this type of alternator.

The development of the alternator has solved another fire department problem. Smoke ejectors and floodlights that require 115 volts previously had to be supplied by a gasoline-driven generator when a second source of electric power was not available. However, both operate very well on the power supplied by the new alternator.

AN INEXPENSIVE INCINERATOR

NEIL LEMAY, *Chief Forest Ranger, Forest Protection Division, Wisconsin Conservation Department*

Debris burning has long been a leading cause of uncontrolled fires in Wisconsin. The increasing number of people with summer homes and camps in forests and the growing use of oil or gas to heat rural homes have accentuated the problem.

Wisconsin law does not allow use of outdoor fire in the organized protection districts except for cooking food or warming individuals unless the ground is snow covered or a burning permit has been obtained. Therefore, a burning permit usually must be obtained for disposal of refuse.

A campaign against debris-burning fires indicated the need for a safe and inexpensive incinerator, which in turn would reduce requests for burning permits for debris disposal. Field men met these needs by developing the

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incinerator shown in figure 1. It was widely accepted and stimulated interest in the use of incinerators. Regular manufactured incinerators are readily available from dealers.

Widespread buying and maintenance of safe incinerators has reduced the number of fires resulting from debris burning. Also, the owner and maintainer of a safe incinerator is eligible for a seasonal permit. Thus, he does not need to obtain a permit every time he wants to burn debris, and he can still burn when burning permits are not issued because of High fire danger. Thus, the number of permits to be checked and accounted for has been reduced.

When an incinerator is obtained, the owner requests a seasonal burning permit. He then signs an application containing an agreement to abide by the rules for the use and maintenance of the incinerator. Finally, the incinerator is inspected; if it is approved, a seasonal permit is issued on the standard burning permit form.

An inexpensive sheet giving the construction details and a general statement of use for the incinerator developed by the field men was written and reproduced for free distribution. Its acceptance has been good, and the benefits have been rewarding.

The rules for the use of an incinerator, as agreed upon by the applicant for a seasonal permit, follow:

1. I will confine all of my burning, as it pertains to this permit, inside a metal or masonry incinerator unit which will be inspected and approved by a forest ranger.
2. I will burn within this incinerator only during the hours as listed in the burning permit.
3. I will have a responsible person present and suitable tools available during this burning period.
4. I will not set fire in this incinerator unit during dry, windy weather.
5. I will keep the area surrounding the incinerator unit clean and free of inflammable fuels.
6. I will keep my burning done currently with the need and not allow material to accumulate and overflow the incinerator unit.
7. I will maintain the incinerator unit as prescribed by a forest ranger.

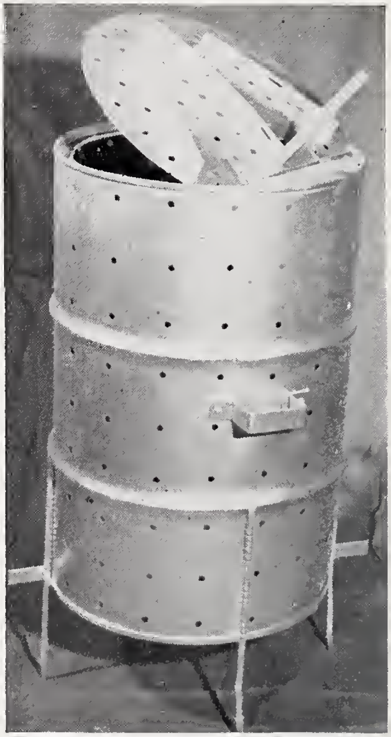

Figure 1.—This inexpensive incinerator was developed for debris burning.

Camera Gunstock—*Continued from page 8*

3- by ⅛-inch metal plate. A knurled-knob camera-thread screw is inserted through this hole. A thin slice of a rubber washer is cemented around the hole to prevent the screw from falling out and to secure the camera in a fixed position. Two holes, for wood screws, are positioned along the outer edge. The way the plate is mounted depends on the camera, lenses, and dexterity of the user. To insure a firm attachment, the metal plate should be cemented to the woodstock. An 18- to 20-inch cable release is inserted through a hole in the hand-grip and stapled to the stock, and it can be attached to the camera. This procedure enables the photographer to operate the shutter and point the camera with one hand while the other hand is free to focus, etc. An over-the-shoulder carrying strap can be added.

The gunstock mount was copied from a readymade item and has been used successfully with a Honeywell Pentax with a 300-mm. lens.

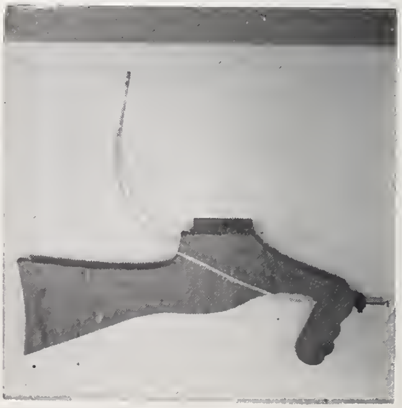

Figure 1.—This gunstock mount is used to steady the telephoto lens of a camera.

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FIRE CONTROL NOTES

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FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

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COVER—This U.S. Marine Corps HR2S helicopter is dropping 450 gallons of water. See story on page 4.

(NOTE—Use of trade names is for information purposes and does not imply endorsement by the U.S. Department of Agriculture.)

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DOUSING SNAGS WITH CHOPPERS

DOUG BAKER, *Forester,*
Rogue River National Forest

On May 5, 1966, lightning struck a ridge and started the Scorpion fire on the Tiller District of the Umpqua National Forest (Oregon). When fire control personnel arrived, the fire was burning in a snag patch on a north aspect in the center of the old Beaver Creek burn. It covered about 35 acres, was 40 chains long, and was 2,900 to 3,300 feet in elevation. The top of the fire was on a ridge, while the bottom was 300 to 400 feet above the creekbed. A south aspect snag patch was just across the creek, which was about 2 feet wide and 6 inches deep. The fire was spreading from snag to snag; as the snags burned and fell to the ground, ground fire began below. There was little if any spread on the ground. There were 42.5 snags per acre, averaging 2.85 feet in diameter, and most of them were broken topped Douglas-fir with top rot exposed in the breaks. The fire was spreading erratically, driven by gusty winds from local thunderstorms, and was spotting downhill from the top of the ridge, where the fire had started.

From our vantage point, a heliport 600 feet horizontally and 300 feet vertically east of the east edge of the fire, we could see 40 percent of the fire area and could observe firespread and wind currents fairly well. A previously constructed helispot was 800 feet below the fire on the "stinger" of Scorpion Ridge. The heliport, which was on an adequate road, was about 1 hour's drive from the Tiller ranger station.

Since the spread was entirely by snags and ground control was not a serious problem, we concentrated on putting a fireline around the area the first night. Then at daybreak we planned to stop the spread of the snag fires by using aerial retardants and by falling the snags within the fire area. We had to fell the snags while we still had cloudy weather with 40 to 60 percent humidity accompanying the lightning and gusty winds. However, it was necessary to change our plans when we found that fixed-wing tankers and retardants would not be available.

We had one Hiller 12E helicopter on the fire, and the pilot had saddle tanks available. He said he could put water on a snag or a flareup without difficulty at our elevation. We requested a set of saddle tanks and were sent a second helicopter equipped with such tanks. We also ordered the supply pumper for the helicopters, and the saddle tanks for the first helicopter were received with the pumper.

We began snag felling at 6:30 a.m. on May 6. We immediately faced the normal problem of felling Douglas-fir snags. The snags were on fire, and the falling embers had piled up around the base until the fellers couldn't get close. The lack of retardants required that additional snags be felled around the fire perimeter to stop the fire spread.

We then began our helitanker operation; we put 80 gallons of water on both helicopters and dropped the water on the snags. The felling crew then moved in and cut the snags. More water was available if it was needed to cool the area. The loading time for each chopper was 2 minutes, and the flight time averaged another 2 minutes. During the first hour of operation the two helicopters, with plenty of targets, dropped more than 2,000 gallons of water on the fire. We added detergent to the tanks as they were being filled, providing wet water for the operation. With 20 sets of snag fallers being supplied by two helicopters, most of the approximately 2,000 snags on the fire were felled the first day. In addition to time spent moving personnel and observing the fire, the choppers were used for almost 9 hours of flying time on water-dropping operations. They dropped 10,730 gallons of wet water on the fire. The cost per gallon of water, which was dropped very accurately on the fire, was a little less than 10 cents. The operation was very safe because flying speeds were low and visibility was good from the low altitudes used. The water dropped was not hazardous to ground crewmen because the small volumes dropped impacted at low speeds. The accuracy was excellent but could be improved with larger tank openings. The choppers couldn't hover with loaded tanks, so the drops were made at a forward speed of about 5 miles per hour.

In summary, using helicopters to drop wet water is a feasible, efficient, and fairly inexpensive method of putting water on selected portions of fires. It is especially effective on snag fires in rough country. Its efficiency would be less at higher elevations, but the severity of the problem would be less, so use of choppers with reduced loads could be considered up to 6,000 feet.

MASS HELITACK ON LARGE FIRES IN CALIFORNIA

MARVIN DODGE,[1]
State Forest Ranger,
California Division of Forestry

Since helicopters were first positively used on a forest fire, on the Bryant fire, on the Angeles National Forest in southern California in 1947, more and more of these aircraft have been used in fire control. Until 1964, most helicopter attacks have been rather small. Generally, one or two helicopters have ferried crews to otherwise inaccessible firelines, transported supplies to spike camps, dropped water or retardants, and scouted firelines. More than a half-dozen helicopters have rarely been used on one fire or project.

However, in 1964 large-scale attacks by helicopters were used to support firefighting by ground crews on two major fires in southern California. Twenty-six helicopters were used at the peak of the Cozy Dell fire on the San Bernardino National Forest. Nineteen helicopters were used on the Coyote fire on the Los Padres National Forest. These aircraft performed well during both fires and were of great value in their control. An old concept in forest fire control—close air support of ground personnel—was proven applicable to large-scale operations. This paper describes the use of helicopters on these fires and the research planned to make mass helitack even more effective.

THE COZY DELL FIRE

The Cozy Dell fire swept across 18,265 acres of watershed cover from July 21 to July 26.

Both military and civilian helicopters were used.

The U.S. Marine Corps Base at Santa Ana provided the military helicopters. They were used according to a joint program developed by the Marine Corps and the California Division of Forestry. On July 24, the Marines dispatched four HR2S (S-56) helicopters and nine HUS's (S-58's) (fig. 1). One HUS led the other helicopters into the drop area. On July 25, the Marines sent four more of the medium HUS's and one more of the larger HR2S models. During the 2 days these aircraft dropped more than 55,000 gallons of water during 231 drops.

The base heliport was in a large pasture about 3 miles from the fireline. A well in the pasture contained an adequate water supply. Two California State Disaster Office pumper trucks boosted water from the well through 2½-inch hose lines into the helicopter tanks at four fill points. Marine Corps landing officers directed landings and takeoffs, flight patterns, and traffic control to fill points and service areas. Liaison with fireline personnel was handled by California Division of Forestry personnel at the base heliport and in the lead helicopter.

While the Marine helicopters dropped most of the water, commercial helicopters transported per-

TABLE 1.—*Helicopters used on Cozy Dell and Coyote fires*

Helicopters	Designation	Passenger capacity	Weight when empty	Maximum takeoff weight[1]	Retardant carrying capacity
Commercial:		*Number*	*Pounds*	*Pounds*	*Gallons*
Bell	47G-3B1	2	1,772	2,950	100
Do	204B	9	4,600	8,500	320
Hiller	12E	2	1,755	2,800	100
Do	E4	3	1,813	2,800	100
Hughes	300	1	910	1,600	-----
Military:					
Sikorsky	HUS (S-58)	14-20	7,630	13,000	180
Do	HR2S (S-56)	30-36	20,960	31,000	450

[1] Actual figure depends on individual model and accessory equipment.

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[1] The author is on assignment to the Forest Fire Laboratory, Pacific Southwest Forest and Range Experiment Station, Forest Service, USDA, Riverside, Calif.

sonnel, hauled cargo, and scouted the firelines. Seven small private helicopters were used on the fire. A larger Bell 204B carried up to eight men per trip to critical spots on the fireline (table 1).

There were some problems in tactics and coordination. A few retardant drops were made far ahead of the ground crews. These drops were flanked or burnt through before the hand crews could take advantage of them. Also, some crews were too slow in following up the knockdown of hot fire when drops were made right in front of them.

THE COYOTE FIRE

The Coyote fire started on September 22 near Santa Barbara; it was contained on September 30. It burned 67,000 acres of watershed cover and destroyed 161 buildings and damaged 27 others. A high powerline near the origin of the fire limited the initial attack by aircraft. But as the fire spread uphill away from the powerline, "air attack became very effective."[2] If the air attack had not been stopped by darkness, the fire probably would have been held to 250 to 300 acres.

Privately owned helicopters under contract to the Forest Service, the National Park Service, and the California Division of Forestry were used on the Coyote fire.

Most of the helicopters operated were from four base heliports. The main base—a polo field east of Santa Barbara—provided ample space for helicopter operations as well as for the main fire camp. Adequate water was available. Turf designed for polo ponies eliminated the dust problem and seemed to hold up under helicopter traffic. Forest Service helitack crews handled traffic control, landing direction, and loading of cargo and retardants.

Every phase of helitack was used. Some of the operations follow:

1. Small portable pumps were used to pump water from tanks set up on ridges.
2. Water was flown to the ridges by helicopters (helipumpers).
3. Manpower was ferried to remote sections of the fireline.
4. Spike camps were ferried in and supplied with food and water.
5. Fire spread and control line construction was scouted and mapped.
6. Retardant was dropped in close support of ground personnel.
7. Wire was layed for emergency telephone communications.

Much of the retardant (Gelgard) was mixed and loaded at the polo grounds. A 1½-inch hose line, split into two lines with a "Siamese," supplied water to retardant mixing and loading stations. Aardvarks — lightweight eductor-type mixers — mixed 2 pounds of fire retardant in each 100 gallons of water. The retardant was premeasured into coffee cans with snap-on plastic lids. When a helicopter landed, crewmen turned on the water and poured a can of retardant into the Aardvark. The helicopter was usually in the air within 2 minutes. However, the helicopter could not reach the fireline for 15 to 20 minutes.

Retardant mixing and loading were done near the fireline where feasible. Cisterns on ridgetops were used. Tank trucks provided water where roads permitted access to a ridge or other suitable helispot. From these locations, a loaded helicopter would be at the fireline within 2 or 3 minutes after takeoff. A two-man mixing crew with an Aardvark mixer, a lightweight portable pump, and an 80-pound bag of retardant could be flown by helicopter to meet a tank truck on a ridge. The helicopter could be loaded with fire retardant and take off within 10 minutes after landing the mixing crew beside a tank truck or cistern (fig. 1). Eighty pounds of retardant is usually sufficient for the daily mixing needs of two helicopters because retardant drops may be intermittent and the helicopters are often diverted to scouting or crew ferrying.

CONCLUSIONS

Although helicopters have been used in the control of some forest fires since 1947, only a few were generally used on each fire. In 1964 massive air attacks by helicopters were used on major forest fires for close support of ground crews.

(Continued on page 16)

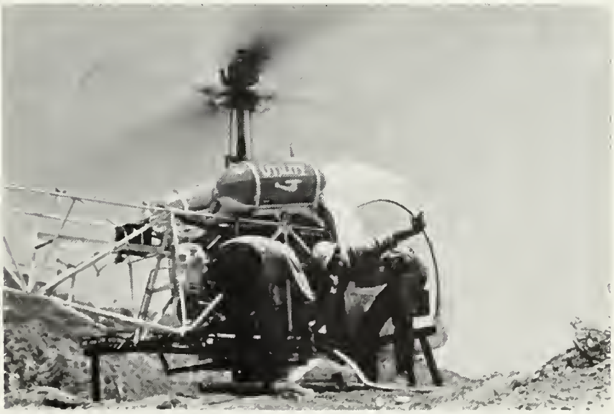

Figure 1.—This Bell 47G helitanker is being loaded at a ridgetop heliport.

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[2] Administrative Fire Analysis, Coyote Fire, September 22-October 1, 1964. Los Padres National Forest, Santa Barbara, Calif.

PHYSIOLOGICAL FACTORS AFFECTING NIGHT HELICOPTER FLIGHT

JAMES P. MORLEY, *Physical Science Technician,*
Pacific Southwest Forest and Range Experiment Station

Editor's Note: Small helicopters will probably soon be operational at night on forest fires. This assertion is based on the results of 3 years of tests and development work at the Missoula Equipment Development Center and the Pacific Southwest Forest and Range Experiment Station. See Fire Control Notes vol. 27, No. 3, July 1966, pp. 12-14.

Have you ever thought of flying over mountains in a helicopter after dark? Studies conducted recently in Montana and California show that night helicopter flying can be fairly safe if trained personnel use specific procedures.

Three of the reasons why firefighting agencies may want their personnel to fly after dark follow:

1. Fire control is likely to be more effective because of reduced fire intensity and rate of spread.
2. Density altitude and air stability are usually more favorable.
3. Helicopters do not have to compete with fixed-wing air tankers and cargo planes for airspace.

Even if you are not a helicopter pilot, the chances are good that in the next 2 or 3 years you will be a passenger in a night operation. What you do in the helicopter can make a big difference in the safety of the operation. Besides having a thorough knowledge of daytime safety rules, you should also be aware of some of the physiological factors that may affect both you and the pilot at night. This paper summarizes the latest aviation and medical information on these factors.

NIGHT VISION

Special ways of using the eyes at night are necessary because vision then is not as clear or as effective as during the day.

The part of the eye that senses light is the retina (in the back of the eye). It is composed of two types of sensory cells: the cones, which are only sensitive to fairly bright light but produce a distinct image; and the rods, which are sensitive to dim light but do not give a very clear image (fig. 1).

The cones are usually clustered in one small section of the retina; light from objects in the center of the field of vision is focused in this section. In fairly bright light, it is best to look directly at an object to take advantage of the sharp image that cones give.

The rods are usually spread out in the area around the section containing the cones; light from objects toward the edges of the field of vision is focused in this area. In dim light it is best to look just to the side of an object to take advantage of the greater sensitivity of the rods. If you lose sight of the object, move your eyes in a circle, always focusing them to the side of the spot where the object was.

In searching a broad area, scan a small area carefully and then shift the eyes to the next area. Move the eyes often but slowly in dim light; the eyes can perceive little while in rapid motion, but they are sensitive just after movement. If the image becomes blurred, blinking may help.

Rods contain a chemical called visual purple, which breaks down in the presence of light. When this breakdown occurs, a message is sent to the brain as light hits each rod. In bright light, much visual purple breaks down, and the rods lose most

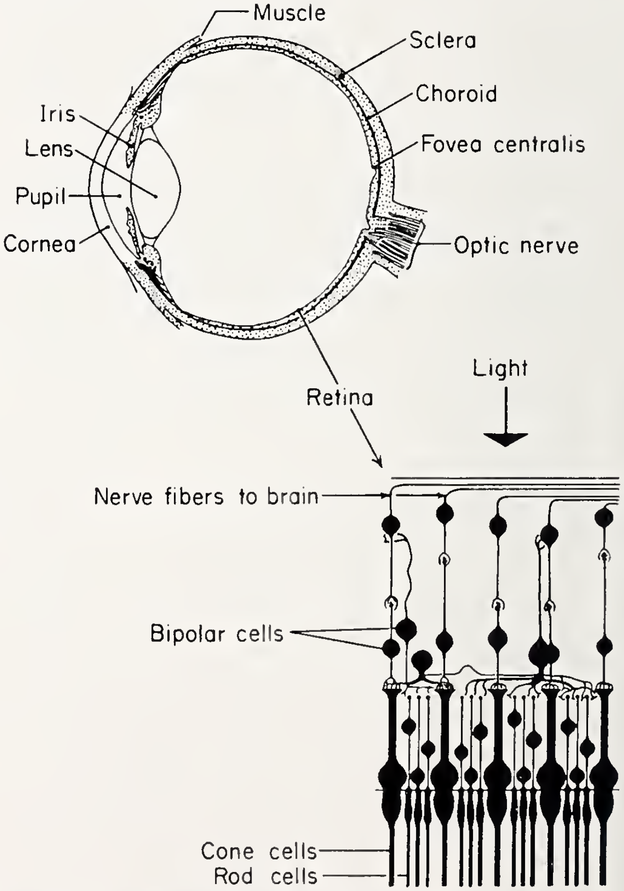

Figure 1.—The retina is the part of the eye that senses light. One group of its sensory cells, the rods, are sensitive to dim light; the other group, the cones, are only sensitive to fairly bright light.

of their usefulness. When dim light returns, the visual purple begins to build up again, but there may not be a useful amount for 15 to 30 minutes. Thus, during night flying, it is important to avoid any exposure to bright light, such as the beam from a flashlight.

ILLUSIONS OF VISION

The pilot's vision is his most vital faculty. But even the best eyes can play unexpected tricks on the most experienced pilot. Some illusions may be quite unexpected.

If you keep your eyes fixed on a single light on a dark night when no other light is visible, that light may appear to move after 10 to 20 seconds even when you know it is stationary. If you stare at the light long enough, you may become almost hypnotized by it, and it will absorb all your attention. The apparent but false movement of a light is called autokinesis. The exact cause of this illusion is not known, but it may be prevented or removed by continually shifting fixation from point to point and by switching on other dim lights in the field of view, such as cabin instrument lights.

Another very confusing illusion is the sudden apparent splitting of light. A single light against a dark background may abruptly appear to split into two or more lights. The muscles that control the movements of the eyeballs have suddenly lost coordination. Closing the eyes briefly or looking at other objects may restore the proper muscle balance—unless the eyes are considerably fatigued.

A pilot sometimes believes that lights or objects in his field of vision have changed their motion or position, and he may not realize that his speed or direction has changed. When instruments are available, the pilot should use them to determine his motion. When they are not available, he will find known stationary ground objects (such as buildings, hills, etc.) to be useful references. Most pilots will try to avoid flying when no known sources of reference are visible, such as during fog, because direction and motion become almost impossible to determine. Do not ask the pilot to fly in visibility conditions he believes are or may become hazardous.

At high speeds, the pilot's normal sense of direction and motion may not be effective.

Illusions are aggravated by physical fatigue, alcoholic hangover, hunger, excessive flying, and monotony.

FLICKER VERTIGO

Flicker vertigo results from exposure to intense light flickering at frequencies of 10 to 30 per second. They can be produced by an idling propeller or rotor in the path of sunlight or by any other source of intense flickering light, such as an unauthorized night marker light.[1]

Flicker vertigo may come suddenly, but there is usually a brief warning, such as uneasiness or intense feeling of discomfort. The first impression is that a light source has suddenly increased in intensity, or that it has expanded so quickly that it fills your entire field of vision. If the condition becomes worse, you may develop a mental blank and then rapid progressive confusion and inability to speak. You may lose muscular control and your head and eyes may quickly and irregularly jerk to one side. Abrupt loss of consciousness and even convulsions may follow.

In trying to counteract flicker vertigo, you should keep your eyes open; closing them causes intense white light to filter through as red light, which is most effective in causing flicker vertigo. Instead, you should turn your head away from the path of light or block the light with your hand or forearm, being careful to avoid pressure on the eyes themselves.

Sensitivity to this condition is greatly increased by emotional excitement, fatigue, and stimulants or sedatives.

MOTION VERTIGO

Mechanisms in your inner ear detect tilt, movement, and rotation of your body and send this information to your brain. Under most circumstances, these organs give accurate reports when movements are not extremely slow or extremely abrupt, when turns are 90° or less, when accelerations and gravitational forces are normal, and when body support is stable. However, accurate reports are often not given. For example, if you are tilted or turned slowly, you may not be able to detect the motion accurately, if at all.

After receiving information on motion, your brain sends a message to your muscles. This signaling normally results in quick adjustment of your body to changes of its position in space. If this adjustment cannot be made, either because your detecting mechanisms are not working properly or because your body cannot make the proper adjustments, dizziness or motion vertigo will probably result. The symptoms of motion vertigo are sweating, nausea, vomiting, inability to stand, and a feeling of spinning or other motion. Ability to adapt to motion varies among individuals. Some people become sick and dizzy on planes and boats while others do not.

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[1] Various flash frequencies are being carefully studied by personnel of the Pacific Southwest Forest and Range Experiment Station, and any lights that may be approved for operational use by the Forest Service will not, in themselves, produce flicker vertigo.

THE CONCEPT OF FIRE ENVIRONMENT

C. M. Countryman, *Research Forester,*
Pacific Southwest Forest and Range Experiment Station

Webster[1] defines "environment" as "2: the surrounding conditions, influences, or forces that influence or modify".

This definition applies to "fire environment" very well. For fire environment is the complex of fuel, topographic, and airmass factors that influences or modifies the inception, growth, and behavior of fire.

Fire environment may be represented by a triangle (fig. 1). The two lower sides of the triangle represent the fuel and topographic components of fire environment. The top side represents the airmass component; this is the "weather" part of the fire environment.

INTERRELATIONSHIPS OF COMPONENTS

Fire environment is not static, but varies widely in horizontal and vertical space, and in time. The fire environment components and many of their factors are closely interrelated. Thus, the current state of one factor depends on the state of the other factors. Also, a change in one factor can start a chain of reactions that can affect the other factors.

For example, consider the simple topographic factor of slope aspect. The amount of heating of fuel by the sun on a slope depends partly on aspect. A slope facing east begins to warm first, and its maximum temperature occurs early in the day (fig. 2*A*). A slope facing south reaches its maximum temperature about 2 hours later, and it is higher than the maximum of the east-facing slope (fig. 2*B*). A slope facing west reaches its maximum temperature still later, and this maximum is higher than those of the east and south slopes (fig. 2*C*). The north slope also has its distinctive diurnal trend (fig. 2*D*). The data illustrated in figure 2 were obtained from observations taken on a clear day on 45-degree slopes early in July at 42° N. For a different combination of cloud cover, slope, time of year, and latitude, a different pattern would be observed. This differential heating of different aspects affects the probability of fire starts, and also fire growth and behavior.

When the surface of a slope is heated, it transmits this heat to the air above it by conduction, convection, and radiation. The resulting increase in air temperature changes the relative humidity. In addition, local winds also are often strongly affected by the differences in air temperature resulting from the differential heating of slopes of different aspects. These winds are further modified by the configuration of the topography and by the surface fuels. Since the moisture content of fine dead woody fuels depends primarily on the relative humidity of the

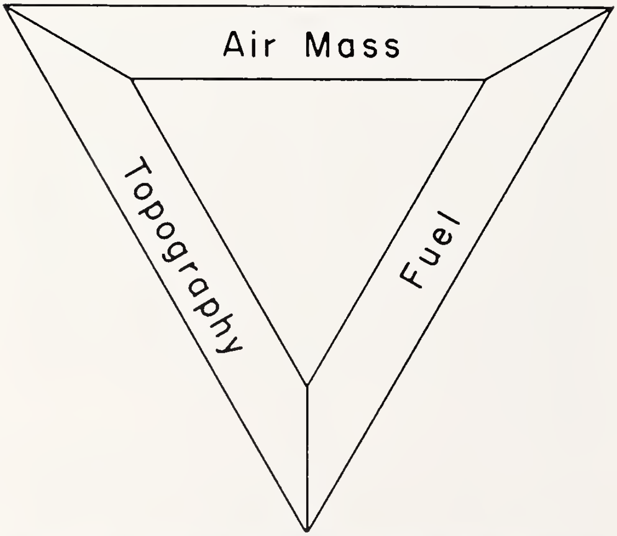

Figure 1.—Fire environment may be represented by a triangle. Each side represents a component of fire environment.

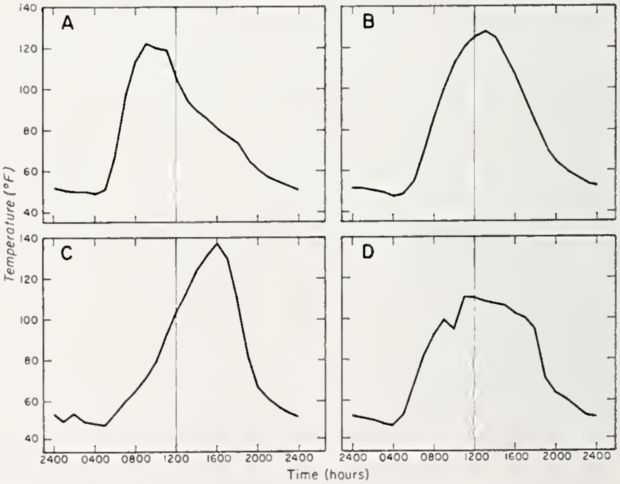

Figure 2.—Relationship of temperature to time of day on 45-degree slopes facing in four directions: *A*, East, *B*, south, *C*, west, and *D*, north. Data were taken on a clear day early in July at 42° N.

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[1] G. & C. Merriam Co. Webster's Third International Unabridged Dictionary, p. 760. 1961.

air, the differences in heating of slopes can affect both fuel moisture content and fuel temperature. The amount of heating of fuels, vegetative or urban, on the surface is affected by airmass conditions such as clouds, moisture content, and windspeed.

FIRE AND FIRE ENVIRONMENT

Where does fire fit into this picture? In an environment without fire, radiant energy from the sun is almost the only source of heat. This energy heats the earth's surface and to a minor extent the air above it. Most of the energy that directly and indirectly modifies the airmass and fuel components of fire environment comes from the heated earth surface. Because of differences in slope, aspect, and ground cover, heating by the sun is not uniform—some areas become much warmer than others. This variation in the local heat sources creates the variability in local weather and fuel conditions.

Perhaps we can most simply consider fire as just another local heat source. As a heat source it reacts with its surroundings in the same way as other local heat sources: interacting with the airmass to create changes in local weather, and with the fuel to modify fuel moisture and temperature. Because of the high temperatures in a fire, however, the reaction can be much more violent.

By adding fire to the center of the fire *environment* triangle (fig. 1), this symbol becomes the fire *behavior* triangle. It is the current state of each of the environmental components—topography, fuel, and airmass—and their interactions with each other and with fire that determines the characteristics and behavior of a fire at any given moment.

FIRE ENVIRONMENT PATTERNS

Because fire behavior and fire environment are interdependent, changes in one will cause changes in the other. To understand or predict fire behavior, we must look at the fire behavior and the fire environment at all points of the fire. Thus, both fire behavior and fire environment are pattern phenomena.

The scope of the fire environment depends primarily on the size and characteristics of the fire. For a very small fire, the environment is a few feet horizontally and vertically. For a large fire, it may cover many miles horizontally and extend thousands of feet vertically. An intensely burning fire will involve a larger environmental envelope than one burning at a lower combustion rate.

OPEN AND CLOSED FIRE ENVIRONMENTS

From a fire behavior standpoint, fire environment can be separated into two general classes: (1) closed environment and (2) open environment. Inside a building, for example, the fire environment is nearly independent of outside conditions. Fuel characteristics are determined by the construction of the building and by its contents. The climate, and hence, the moisture content of the hygroscopic fuels, is controlled by the heating and cooling systems. Air movement and topographic effects are nearly nonexistent. This is confined or 'closed" environment. However, the environment outside buildings is not confined. Current airmass characteristics vary with the synoptic weather patterns and local conditions. Wind movement and topographic effects prevail. This is "open" environment.

Fire burning inside a building is controlled by the fire environment within the building. The outside environment has little effect. As long as the fire remains within the building (fig. 3*A*), there can be no spread to adjacent fuel elements. The fire is confined.

If the fire breaks out of the building, it is no longer burning in a closed environment. Outside conditions can influence its behavior, and the fire can spread to other fuel and grow in size and intensity (fig. 3*B*).

Closed and open environments also exist in wildland fuels; however, the boundaries between the two environments are not as clear as they are in urban areas.

For example, a fire burning under a dense timber stand (fig. 3*C*) is burning in an environment that may be much different than that above or outside the stand. Fuel moisture is often higher, daytime temperature is lower, and windspeed is much slower. In this situation the fire is burning in a closed environment.

If the fire builds in intensity and breaks out through the crowns of the trees (fig. 3*D*), it is burning in an open environment and can come under an entirely different set of controls. Fire behavior and characteristics can change radically.

Open and closed environments exist in other fuels as well as timber, such as grass and brush. Because of the short vertical extent of these fuels, the probability of fire burning entirely in a closed environment is much less. But the closed fire environment in a fuel bed influences fire behavior, even if only part of the fire is burning in a closed environment.

The most obvious use of the concept of fire environment and fire behavior patterns is probably in understanding and predicting wildfire behavior, but the concept can also be used in prescribed burning. In fires of low or moderate intensity, which are usually desired in prescribed burning, the fire environment pattern largely controls the behavior pattern. Thus, by knowing the fire environment pattern for the area, the fire behavior pattern can be predicted. And by selecting the proper environment pattern, the desired type of behavior can be obtained and dangerous points can be alleviated.

SUMMARY

Fire environment is the complex of fuel, topographic, and airmass factors that influences or modifies the inception, growth, and behavior of fire. It is the current state of these factors and their interrelationship with one another and with fire that determines the behavior and characteristics of a fire at any given moment. Fire environment is not static, but varies widely in space and time. Both fire environment and fire behavior are pattern phenomena, and both patterns for the area of the fire must be considered in order to understand and predict a fire's behavior. Because of the difference in the fire environment patterns, the behavior of fire burning in a closed environment may be vastly different from one burning in an open environment. The concept of fire environment and fire behavior patterns is useful for the understanding and prediction of fire behavior for both wildfires and prescribed fires.

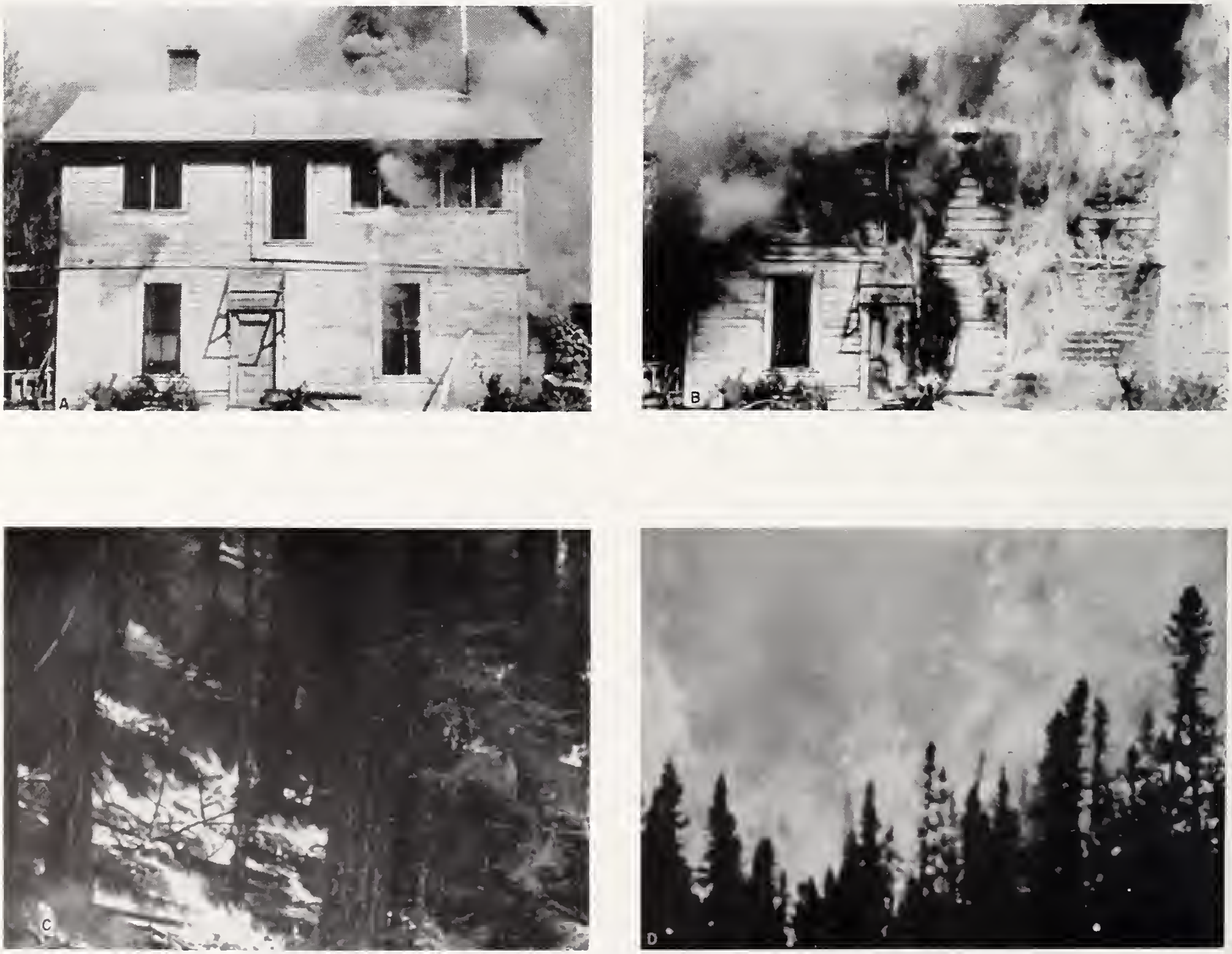

Figure 3.—These fires are burning in the following fire environments: A, Closed urban, B, open urban, C, closed wildland, D, open wildland.

QUALITY CONTROL IN FIRE DANGER RATING

JOHN J. KEETCH, *Forester,*
Southeastern Forest Experiment Station

Fire control officers need accurate data to develop, execute, and evaluate their procedures in fire control management. One of the most valuable sources of data for the fire control officer is the fire danger rating. But to use the ratings with confidence, it is imperative to establish and maintain uniform standards of measurement and effective methods of data verification. These are the functions of quality control.

Quality control is much more than a rigorous check of the observer's record sheets. It must start with the fire danger station network and continue through a series of checkpoints to the final computations on the daily record. To clearly define quality control, and what must be done to implement it, this tool is discussed in the following six sections: Site, installation, maintenance, operation, recording, and computation.

SITE

Professional judgment is needed in site selection and equipment installation. Both checkpoints must be standardized so there is a uniform fire danger rating system instead of a series of systems.

The general location and specific site of a station must assume first priority. Readings from instruments that are incorrectly located are wrong and cannot be counterbalanced by the work of the most meticulous observer. If airport-type exposures could always be found, proper site selection would not be difficult. But there are few ideal sites in areas where fire danger stations are needed. Obstructions or unwanted reflecting surfaces are usually present on sites that are convenient for observers. Topography, surrounding woodland, and nearby manmade structures must be carefully considered for their probable effect on each fire danger element to be measured. Also, a thorough understanding of the instrument exposure standards and the basis for them is necessary.

The instructions in chapter 600 of the Forest Service National Fire-Danger Rating System Handbook are the best guides for proper placement of fire danger stations. Specialized training in site selection is also necessary. Experience in site evaluation is vital; therefore, site selection should be a Regional responsibility, and should be made by one qualified staff man.

INSTALLATION

When a good site has been selected, adequate equipment must be properly exposed and correctly installed. The exposure part of the problem is the most difficult, particularly the anemometer installation. At substandard stations where instruments are improperly exposed, the measured elements will, in effect, be weighted differently than was intended in the design of the system.

Only qualified staffmen should give final approval to the placement of instruments, both for the existing network and for new stations. This responsibility includes their recommendations for upgrading or relocating stations that were already approved, but where the immediate environment has changed because of tree growth or the addition of structures, roads, parking areas, or irrigation systems. The standards for installation in chapter 600 are somewhat easier to follow than the rules for site selection, even though acceptable equipment varies somewhat.

MAINTENANCE

Inspection sampling of stations in several Regions has clearly shown that prompt and effective maintenance is one of the most important factors in quality control. Maintenance includes the routine cleaning, minor adjustment, and repair of instruments and their supporting devices according to the guidelines in chapter 800 of the National Fire Danger Rating Handbook. Alertness, mechanical proficiency, and knowledge of the instruments and their mechanisms are required. High maintenance standards are easily achieved; mistakes are almost always due to carelessness rather than to lack of knowledge. Unadjusted anemometer contacts, a reduction in cup rotation because of dirt or lack of oil, unmatched thermometers, dirty wicking, or leaky rain gages inject inescapable errors into the basic fire-danger record.

The professional judgment needed in site selection and installation is not necessary. The primary responsibility is local rather than Regional because effective maintenance requires frequent checking. The network of stations on a National Forest should be checked at least twice each year (see section 890). The results of the semiannual visits will determine which stations require more frequent visits from the local staff officer or designated technician.

OPERATION

When an adequate training program is in effect, the observer must continue correct daily operational procedures. The measurement routine is simple and easily understood. The source of error is

(Continued on page 16)

GET THE MOST FROM YOUR WINDSPEED OBSERVATION

John S. Crosby and Craig C. Chandler[1]

Surface windspeed is often the most critical weather element affecting fire behavior and fire danger. It is also the most variable and, consequently, the hardest to evaluate.

Air moving across the surface of land is constantly changing speed and direction. Standing still, one observes a series of gusts and lulls. Because of gusts, trying to measure windspeed is much like trying to measure the speed of a car on a winding mountain road. It slows on the turns, speeds up on the straightaways, and slows to a crawl on bumpy stretches. To obtain a reliable average speed, one must determine the time required to travel at least 2 miles. And the rougher and more crooked the road, the longer is the distance required to obtain a reliable average. This same principle applies to wind measurements. The greater the gustiness (the ratio between the range in momentary windspeeds and the average speed), the longer it takes to determine a reliable windspeed.

Peak windspeeds that persist for 1 minute can affect gross fire behavior, including rate of spread and fire intensity. For example, a surface fire in pine litter spreading at 10 chains per hour with the wind averaging 5 miles per hour would spread 11 feet farther than expected during a minute when the wind was blowing at 9 miles per hour. During that minute it would burn with twice its average intensity and would be nearly three times as likely to jump a prepared fireline.

Momentary gusts have little effect on the overall rate of fire spread and intensity, but they do produce large fluctuations in flame height and can easily trigger crowning or throw showers of sparks across the fireline when other weather factors are in critical balance. Gusts will usually be close to the average value and will rarely exceed the maximum value.

Gustiness is caused by mechanical and thermal turbulence.

Mechanical turbulence is produced by friction as the air flows over the ground surface. Its magnitude depends on the height above the ground where measurements are made, the roughness of the ground surface, and the windspeed. The maximum mechanical turbulence is found close to the surface in rough topography on windy days.

Thermal turbulence occurs when horizontal wind meets convective currents produced by unequal heating or cooling at the ground. Its magnitude depends mostly on topography, ground cover, solar radiation, and atmospheric stability. The maximum thermal turbu-

Table 1.—*Wind gust estimating table*[1]
(Miles per hour)

Standard 10-minute average	Probable maximum 1-minute speed	Probable momentary gust speed	
		Average	Maximum
1	3	6	9
2	5	8	12
3	6	11	15
4	8	13	17
5	9	15	18
6	10	16	20
7	11	17	21
8	12	19	23
9	13	20	24
10	14	22	26
11	15	23	27
12	17	25	29
13	18	26	30
14	19	28	32
15	20	29	33
16	21	30	35
17	22	32	36
18	23	33	38
19	24	34	39
20	25	35	40
21	26	37	42
22	27	38	43
23	28	39	44
24	29	40	46
25	30	41	47
26	31	43	49
27	32	44	50
28	33	45	51
29	34	46	53
30	35	47	54

[1] All readings were taken in the afternoon 20 feet above the ground.

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[1] Respectively, Research Forester, North Central Forest Experiment Station, Forest Service, USDA, Columbia, Mo., and Assistant Chief, Forest Fire Research Branch, Division of Forest Protection Research, Forest Service, USDA, Washington, D.C.

lence occurs above rough topography with patchy ground cover during sunny afternoons in unstable air.

Gustiness is a serious problem for both fire researchers and fire-control planners. Because of gustiness, wind measurements at two locations cannot be compared unless they are taken at the same height above the ground and for the same length of time. For maximum comparability, measurements should be taken as high above the ground as possible and for as long as possible. But high towers and long observations are expensive. Therefore, for fire-danger rating we have established a standard anemometer height of 20 feet and a standard observation time of 10 minutes.

While these standards are fine for fire-danger rating, they often confuse the firefighter on the ground. Rapid changes in fire behavior are determined by rapid changes in the wind blowing on the burning fuel, and not by changes in the long-term average windspeed 20 feet above ground. Often the firefighter loses confidence in his meteorologist or his weather station, or both, because he is told to expect a 16-mile-per-hour wind and found the fire fanned by 35-mile-per-hour gusts. He often must estimate the variations in windspeed that may be expected for the average speed that is reported.

To help firefighters estimate gustiness, we determined the 10-minute average speed, the probable fastest 1-minute average speeds, and the probable average and highest momentary speed or gust during the fastest 1-minute speed (table 1). The table values were determined from several hundred noon and afternoon observations made at Salem, Mo., during fire seasons. They were taken when gustiness was likely to be greatest, as it often is on difficult fires. Thus, the estimates are most accurate when they are needed the most.

TABLE 2.—*Standard windspeed estimates based on maximum gusts*[1]
(Miles per hour)

Fastest gust observed on hand-held anemometer[2]	Standard windspeed when atmospheric condition is:		
	Stable[3]	Neutral[4]	Unstable[5]
0-3	0	0	0
4-6	1	1	1
7	2	1	1
8	2	2	1
9	3	2	2
10	4	3	3
12	6	4	4
14	8	6	5
16	10	8	7
18	12	9	8
20	15	11	10
22	17	13	12
24	19	15	14
26	22	17	16
28	24	19	18
30	27	21	20
32	29	23	22
34	32	25	23
36	34	27	25
38	37	29	27
40	39	31	29

[1] Standard windspeed is 10-minute average speed 20 feet above the ground.

[2] Readings were taken 5 feet above ground. For best results observations should be made for several minutes.

[3] This column usually should be used for observations between 8 p.m. and 8 a.m.

[4] This column usually should be used for observations between 8 a.m. and noon, and between noon and 8 p.m. on overcast days.

[5] This column usually should be used between noon and 8 p.m. on clear or partly cloudy days.

It is difficult to convert windspeeds taken by firefighters to the standard windspeed. In preparing spot forecasts for project fires, wind measurements are often made with a hand-held anemometer. This instrument indicates gust speed accurately, but it is almost impossible to accurately determine average speed with it. Consequently, the windspeed reported from the fireline almost invariably is the average gust speed rather than the accepted 20-foot, 10-minute standard. Therefore, another table was developed to convert gust speed 5 feet above the ground to the standard 20-foot, 10-minute speed for stable, neutral, and unstable conditions (table 2). This conversion should be used when fire-danger indexes are determined from fireline observations or when wind information consists of a mixture of hand-held and tower observations.

ONTARIO TESTS A NEW TYPE OF FOREST FIRE HOSE

G. P. Elliot,
Forest Protection Supervisor, Cochrane District
Ontario Department of Lands and Forests

Ontario is one of the largest users of forest fire hose in Canada. The Ontario Department of Lands and Forests maintains approximately 31,000 lengths of hose at its various headquarters strategically located in the Province.

The capital investment for this hose is approximately $1 million. Also, much of this hose must be replaced each year because of various causes of failure. Replacement costs are almost half of the annual expenditure for fire suppression equipment.

This high rate of replacement has stimulated an endeavor to find hose with a longer useable life. Requirements include resistance to burning, ability to transmit water with low friction loss, and durability and mobility.

Two types of forest fire hose are used in Ontario:

1. Lined hose is used to deliver water to the fireline. It has low friction loss and withstands high pressures, which is desirable for this part of the hoselay. Lined hose is not resistant to burning if exposed to direct heat and flame.
2. Unlined linen hose is used at the fire perimeter. This hose with its weeping characteristic does not burn under pressure.

An ideal hose should incorporate these features:

1. Low friction loss
2. High resistance to burning under pressure
3. Ability to withstand high pressures
4. Resistance to abrasion in handling and storage
5. Flexibility when dry or wet

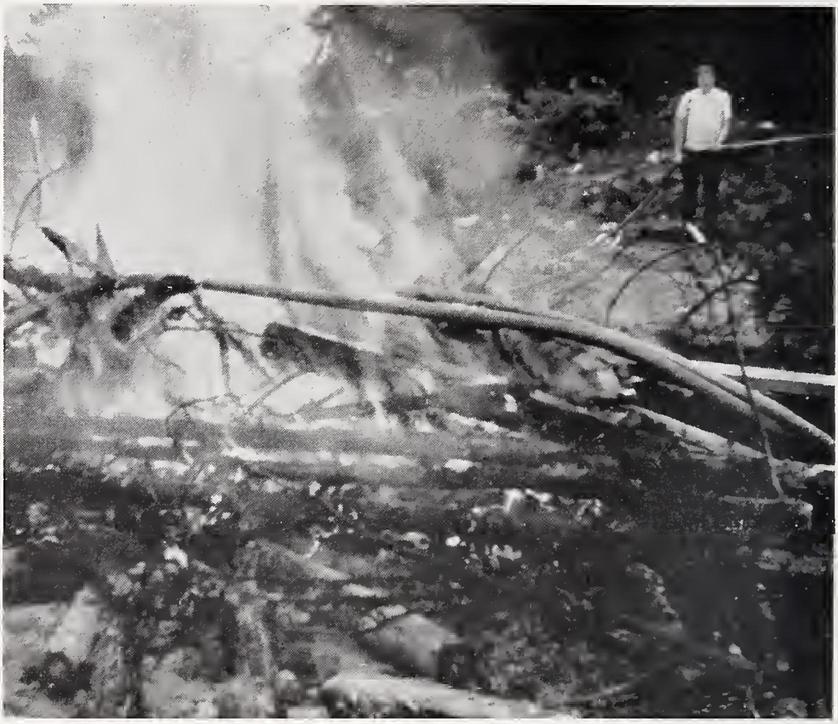

Figure 1.—This self-wetting or percolating type of lined hose can withstand fire.

A percolating lined hose (fig. 1) that meets most of these requirements has been manufactured. It is a composite of natural fibres and synthetics.

In 1964 this new type of forestry hose was supplied to the Ontario Department of Lands and Forests for evaluation tests. Test results indicated that the friction loss ratio of the new hose was approximately 50 to 70 percent of the difference between standard types of unlined and lined hose. Its weeping capacity provides resistance to damage by heat or flame. Its weight and flexibility correspond with standard types. Its flexibility is satisfactory for handling and packing procedures now used.

This initial investigation resulted in a recommendation to purchase a certain quantity of self-percolating hose for field testing. Some hose was tested during the 1965 fire season, and initial reports appear favourable. All field establishments will have this hose during the 1966 fire season. Therefore, data on its performance and durability will soon be available.

This new type of percolating lined hose is a major improvement. However, the search for a better type of forest fire hose is being continued in Ontario.

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Mass Helitack—Continued from page 5

Close ground support by helicopters speeded control. Effective retardant drops knocked down hot spots just ahead of the crews. They greatly reduced the hazard to the firefighters, particularly when flareups on slopes below the crews could have forced a retreat. Often the crews did not have to battle hot fire to put in control lines. Also, hot spotting ahead of the crews by the helicopters slowed the fire spread and shortened the control line that did have to be built. However, the crews still had hard work in heavy brush and on steep, rough topography.

The mass use of helicopters in the control of both fires emphasized problems that need further study. Foremost among these are:

1. The use of helicopters at night. Air conditions then are more favorable, and because fires usually are not as intense at night, control would generally be easier.
2. The close coordination of helicopters with other aircraft, ground equipment, and ground crews. Research in systems analysis is needed to help develop the optimum balance among all types of firefighting forces.

Studies on both problems are now being conducted by the Forest Service.

Quality Control—Continued from page 11

usually carelessness and intermittent lack of attention to detail in the day-after-day routine.

The selection and training of observers and followup is primarily a local responsibility. Almost daily contact may be needed for some time, especially with new observers. Thus, the district in which the station is located should have direct responsibility for correct operation.

RECORDING

The accurate and legible recording of observed data may be considered a part of operation, and the level of responsibility is the same. It is discussed separately, however, because an excellent record taker may be a poor record keeper. Even when a station is perfectly installed, maintained, and operated, a record with indistinct or uncertain entries is useless as a source of future information. Observers must understand that their work is of permanent value.

However, observers, in their zeal to make clear and legible records, have sometimes hand copied or typed the original data from a scratch sheet. This, most emphatically, should not be done. Mistakes in copying are easily made, and many such errors have been noted. Exactness in preparing the original record, with use of carbon for copies that are needed, is all that is required.

COMPUTATION

When the data are in order, the buildup index, spread index, or other operational indexes must be correctly computed. Errors in computation are not as serious as mistakes in previous sections because corrections can be made. For example, poor exposure or a faulty anemometer may result in the recording of windspeed as 10 m.p.h. instead of the correct 15 m.p.h. Moreover, such an error would probably not be detected in a review of the record. But the same error in computation, resulting in an incorrect spread index, could easily be found by recomputing. Thus, the final step in quality control should be to completely recheck all computations.

This computation should be done at the district level because any sizable error will adversely affect preparedness action. Moreover, any questionable items can be discussed directly with the observer, and it is a good training measure.

The records from a National Forest network should be cumulated in the Supervisor's office and spot checked. Comparative checking at the Forest level may reveal inconsistencies that were not apparent at the source.

Fire danger data forwarded from the Supervisor's office, either to the Region, Fire Research Center, U.S. Weather Bureau, or other cooperators, should be as free from error as is possible if all six steps in quality control have been successful.